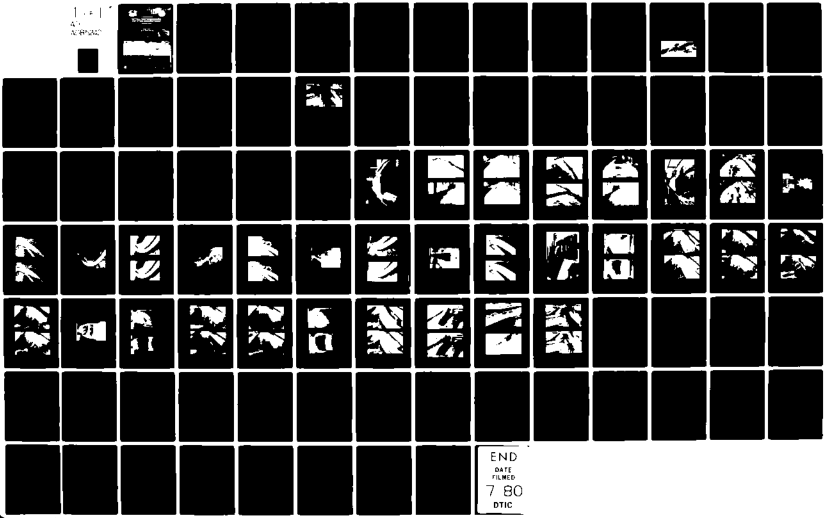
AD-A085 242   ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/G 13/2
BALD EAGLE CREEK AND LITTLE JUNIATA RIVER CHANNEL IMPROVEMENT P--ETC(U)
APR 80 J F GEORGE
UNCLASSIFIED WES/TR/HL-80-5 NL



Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
Technical Report HL-80-5

2. GOVT ACCESSION NO.
AD-A085242

3. RECIPIENT'S CATALOG NUMBER

9

4. TITLE (and Subtitle)

6

BALD EAGLE CREEK AND LITTLE JUNIATA RIVER CHANNEL IMPROVEMENT PROJECT; Hydraulic Model Investigation

5. TYPE OF REPORT & PERIOD COVERED
Final report, Dec 76 - Mar 79

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

10

John F. George

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
U. S. Army Engineer Waterways Experiment Station
Hydraulics Laboratory
P. O. Box 631, Vicksburg, Miss. 39180

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
U. S. Army Engineer District, Baltimore
P. O. Box 1715
Baltimore, Md. 21203

12. REPORT DATE

11

Apr[redacted]80

13. NUMBER OF PAGES
75

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

12 92

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

14 WES/TR/HL-80-5

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Bald Eagle Creek
Channel flow
Channel improvement
Hydraulic models
Little Juniata River

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Tests were conducted on a 1:25-scale model of Bald Eagle Creek and the Little Juniata River to determine the adequacy of proposed channel improvements included in the Tyrone Flood Control Project. The model reproduced approximately 5,340 ft of Bald Eagle Creek which consisted of Westvaco Dam, the transition immediately downstream, the high-velocity channel with superelevated curves, the stilling basin, and approximately 800 ft of the Little Juniata River including its confluence with Bald Eagle Creek.

(Continued)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

411389

20. ABSTRACT (Continued).

Unsymmetrical approach conditions upstream of Westvaco Dam resulted in unequal flow distribution across the dam. This caused cross waves to develop in the transition section downstream of Westvaco Dam. Modification of the left slope of the existing topography and placement of a curved wing wall on the right abutment of the dam improved the flow distribution across the dam and reduced the cross waves in the transition section immediately downstream. Extension of the right vertical wall of the transition 290 ft upstream with the slope modification in place also improved the flow distribution across the dam and reduced the cross waves in the transition.

Flow conditions were satisfactory throughout the high-velocity channel. Wall heights were adequate to contain the design discharge of 13,400 cfs.

Unsatisfactory flow conditions were observed in the Bald Eagle Creek stilling basin and at its confluence with the Little Juniata River for both design flood conditions of 13,400 cfs in Bald Eagle Creek with no flow in the Little Juniata River, and 29,300 cfs in the Little Juniata River with 11,000 cfs in Bald Eagle Creek. The confluence was modified to provide satisfactory flow conditions downstream of the confluence for both design flood conditions. However, unsatisfactory flow conditions persisted in the stilling basin during flood flows in the Little Juniata River, regardless of modifications tested because of the excessive tailwater depths present in the stilling basin.

The optimum riprap and gabion protection plans were determined for the bank slopes in the Little Juniata River.

PREFACE

The model investigation reported herein was authorized by the Office, Chief of Engineers (OCE), U. S. Army, on 18 March 1976, at the request of the U. S. Army Engineer District, Baltimore. The studies were conducted by personnel of the Hydraulics Laboratory, U. S. Army Engineer Waterways Experiment Station (WES), during the period December 1976 to March 1979. All studies were conducted under the direction of Messrs. H. B. Simmons, Chief of the Hydraulics Laboratory, and J. L. Grace, Jr., Chief of the Hydraulic Structures Division. The tests were conducted by Messrs. J. F. George, H. H. Allen, J. H. Riley, S. H. Headley II, and C. L. Dent under the supervision of Mr. G. A. Pickering, Chief of the Locks and Conduits Branch. This report was prepared by Mr. George.

Messrs. Samuel B. Powell of OCE; E. Lally of the U. S. Army Engineer Division, North Atlantic; D. Mahoney, D. Strong, and D. Seibel of the Baltimore District; and A. Hooke, Contractor, visited WES during the study to discuss test results and to correlate these results with concurrent design work.

Commanders and Directors of WES during the testing program and the preparation and publication of this report were COL John L. Cannon, CE, and COL Nelson P. Conover, CE. Technical Director was Mr. F. R. Brown.

A

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
cubic feet per second	0.02831685	cubic metres per second
feet	0.3048	metres
feet per second	0.3048	metres per second
inches	25.4	millimetres
miles (U. S. statute)	1.609344	kilometres
pounds (mass)	0.4535924	kilograms

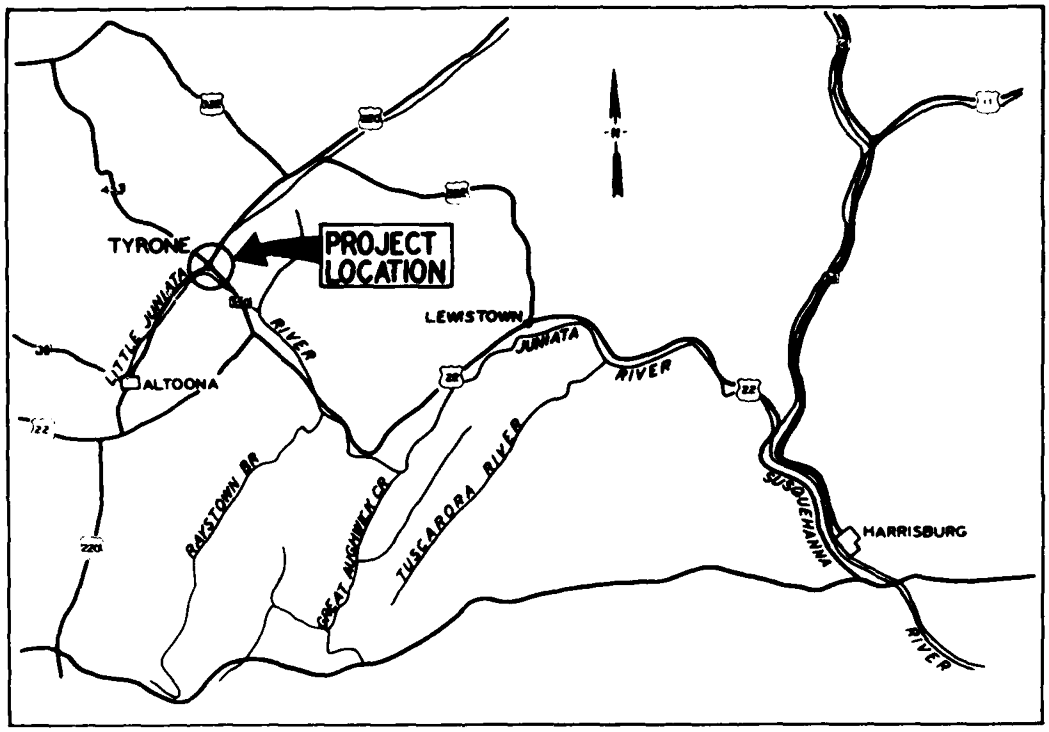


Figure 1. Location map

BALD EAGLE CREEK AND LITTLE JUNIATA RIVER
CHANNEL IMPROVEMENT PROJECT

Hydraulic Model Investigation

PART I: INTRODUCTION

The Prototype

1. The Tyrone Flood Control Project is designed to provide fluvial flood protection for the city of Tyrone, Pennsylvania, located approximately 200 miles* northwest of Washington, D. C. (Figure 1). The area surrounding the city is mountainous and ranges in elevation from 800 to 2,500 ft above mean sea level. The principal streams flowing through Tyrone are the Little Juniata River and Bald Eagle Creek.

2. The proposed improvements of the flood control project will begin just upstream of Westvaco Dam on Bald Eagle Creek and extend downstream to the Little Juniata River. These improvements consist of a new levee and wall on the right bank adjacent to the Westvaco Plant, a concrete overflow dam founded on steel sheet piling, a concrete flume with a low-flow notch, a stilling basin, and interior drainage facilities. Other proposed improvements included in the flood control project are on the Little Juniata River. These improvements consist of levees and walls along the left and right banks, a drop structure with a fish ladder, improvements in the river, a fish channel, protection of bridge piers and abutments, structures on tributaries, and interior drainage facilities.

Project Design Floods

3. The proposed flood control project will be designed for peak discharges occurring in Bald Eagle Creek and the Little Juniata River.

---

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

The protective works in Bald Eagle Creek will be designed for a peak discharge of 13,400 cfs with no flow in the Little Juniata River. Channel improvements on the Little Juniata River will be designed for a peak discharge of 29,300 cfs upstream of Bald Eagle Creek and for an increased peak discharge of 40,300 cfs downstream of Bald Eagle Creek.

Purpose of Model Investigation

4. A model was considered necessary to verify the adequacy of and develop desirable modifications to the transition upstream from the high-velocity channel, the superelevated curves, the stilling basin, and the confluence of Bald Eagle Creek and the Little Juniata River. Specifically, the model study was to determine:

- a. Flow conditions resulting from junctions, expansions, contractions, and bridge piers.
- b. Water-surface elevations at various areas throughout the project.
- c. Performance of the stilling basin for various flow conditions.
- d. Optimum riprap and gabion bank slope protection plans on the Little Juniata River.

PART II: THE MODEL

Description

5. The 1:25-scale model reproduced approximately 5,340 ft of Bald Eagle Creek beginning 225 ft upstream of Westvaco Dam and terminating at the Little Juniata River, and 800 ft of the Little Juniata River beginning 410 ft upstream of the Bald Eagle Creek-Little Juniata River confluence (Figure 2, Plates 1 and 2). The proposed vertical walls, portions of the channel invert not superelevated, and the stilling basin were constructed of plastic-coated plywoods. Westvaco Dam and the superelevated channel invert were constructed of concrete with a very smooth finish, and all bridges and bridge piers were constructed of transparent plastic. Initially, portions of the model were molded in sand and cement mortar to sheet-metal templates to test the structures within the channel. In later tests, the cement mortar was replaced with riprap or gabions to determine the optimum bank protection requirements with the recommended structures. The gabions consisted of wire baskets filled with rock. Filter cloth was placed between the sand and graded riprap or gabions for all bank slope protection tests.

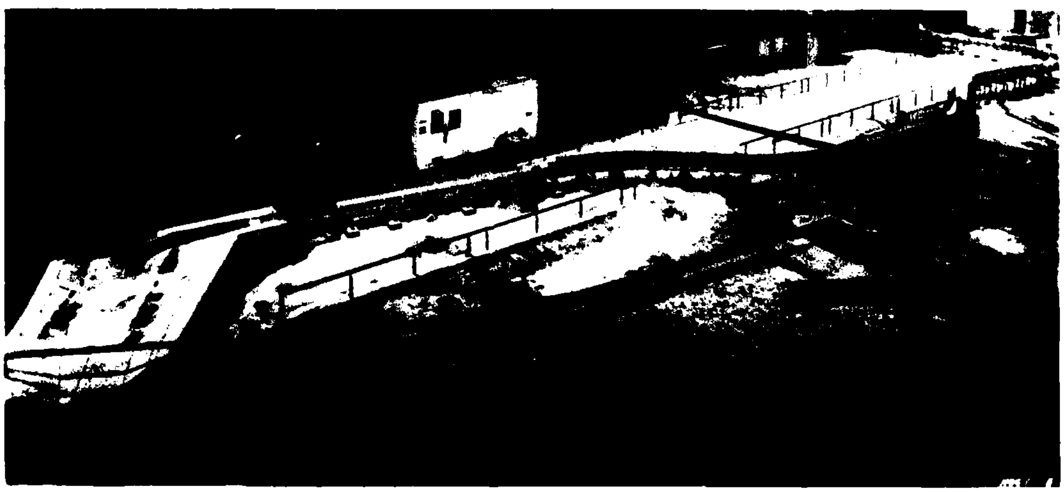


Figure 2. General view of model

6. The coefficient of roughness of the model surface of the high-velocity channel had previously been determined to be approximately 0.009 (Manning's n). Basing similitude on the Froudian relation, the above n value would be equivalent to a prototype n of 0.0154. The n value used in the design and analysis of the prototype channel was 0.014; therefore, *supplementary slopes* were added to the model to correct for this difference in the n values of the model and prototype.

Model Appurtenances

7. Water used in the operation of the model was supplied by a circulating system. Discharges were measured by means of venturi meters installed in the flow lines and were baffled when entering the model. Velocities were measured with pitot tubes that were mounted to permit measurement of flow from any direction and at any depth. Water-surface elevations were measured with point gages. Different designs, along with various flow conditions, were recorded photographically.

Scale Relations

8. The accepted equations of hydraulic similitude, based on the *Froudian criteria*, were used to express mathematical relations between the dimensions and hydraulic quantities of the model and prototype. General relations for the transference of model data to prototype equivalents are presented below:

Characteristic	Dimension*	Model:Prototype
Length	L_r	1:25
Area	$A_r = L_r^2$	1:625
Velocity	$V_r = L_r^{1/2}$	1:5

(Continued)

* Dimensions are in terms of length.

Characteristic	Dimension	Model:Prototype
Discharge	$Q_r = L_r^{5/2}$	1:3,125
Volume	$V_r = L_r^3$	1:15,625
Weight	$W_r = L_r^3$	1:15,625
Time	$T_r = L_r^{1/2}$	1:5

Model measurements of discharge, water-surface elevations, and velocities can be transferred quantitatively to prototype equivalents by means of the scale relations. Experimental data also indicate that the model-to-prototype scale ratio is valid for scaling riprap in the sizes used in this investigation.

PART III: TESTS AND RESULTS

9. Tests were conducted to observe general flow conditions and to determine the adequacy of the channel improvements in Bald Eagle Creek and the Little Juniata River. Results of tests pertinent to each component of the project will be discussed in order of its position, beginning in Bald Eagle Creek in the approach channel upstream of Westvaco Dam and proceeding in a downstream direction.

Approach to Westvaco Dam

Original design

10. Flow conditions with discharges ranging from 500 to 13,400 cfs (design discharge) were observed upstream of Westvaco Dam (Plate 3) and found to be unsatisfactory due to the unsymmetrical approach conditions to the dam (Photo 1, Plate 4). The approach conditions resulted in unequal flow distribution across the dam which caused large cross waves to develop in the transition section downstream of Westvaco Dam during the design discharge. A buildup of flow occurred along the left side of the dam (Photo 2) due to the upstream topography. Drawdown in the water surface occurred at the right abutment of Westvaco Dam and along the upstream end of the right wall (sta 59+46.19) which produced a small cross wave immediately downstream (Photo 3). Photographs of flow conditions and velocities measured upstream of Westvaco Dam are shown in Photo 4 and Plate 5, respectively. Water-surface profiles are shown in Plates 6 and 7 with elevations listed in Tables 1 and 2.

Alternate designs

11. Several modifications to the existing topography on the left side (looking downstream) upstream of Westvaco Dam were tested in an effort to reduce the buildup of flow that occurred along the left abutment of the dam. A 1V-on-2.5H tapering slope (type 2) shown in Photo 5, reduced the buildup of flow along the left abutment considerably, thus decreasing the height of cross waves immediately downstream (Photo 6).

12. Various curved wing walls were tested on the right abutment in

order to reduce the drawdown in water surface that occurred at the right abutment. The type 3 wing wall modification with a 25-ft radius (Photo 7) resulted in improved flow conditions in the transition section immediately downstream (Photo 8). Rectangular slots, 1 ft wide by 2 ft high, at the bottom of the wing wall (Photo 7) allowed circulation of flow behind the wall, thereby eliminating stagnant conditions that could develop in front of the existing intake structure. Flow conditions in the vicinity of Westvaco Dam with the type 3 modification are shown in Photo 9. Water-surface profiles and elevations are provided in Plate 8 and Table 3, respectively. Velocities measured upstream of Westvaco Dam are shown in Plate 9.

13. Although the type 3 modification produced satisfactory flow conditions, tests were conducted with a straight wall on the right abutment since there was some question as to the construction of the curved wall. This modification (type 4) consisted of extending the right transition wall approximately 290 ft upstream of Westvaco Dam. The vertical wall was approximately 17 ft high. Due to the physical limits of the model, only 260 ft of the wall was reproduced (Photo 10a). The left slope modification (type 2) upstream of Westvaco Dam was also in place during these tests.

14. Flow conditions with the type 4 modification were observed with discharges ranging from 2,000 to 13,400 cfs. Satisfactory flow conditions (Photo 10b) occurred upstream of Westvaco Dam and in the transition immediately downstream. However, with the design discharge, the water surface slightly overtopped the right transition wall at sta 56+60 (Plate 8). The type 4 modification improved flow distribution across the dam and reduced the cross waves that developed in the transition with the original design; but the reduction in cross-wave heights was not as significant as that with the type 3 curved wing wall. Water-surface elevations are tabulated in Table 4 and velocities are shown in Plate 10.

Westvaco Dam discharge calibration

15. Discharge calibration data were obtained for Westvaco Dam with the type 1 (original) design and with types 3 and 4 modifications upstream of Westvaco Dam. The type 2 slope modification was in place when

calibration data were obtained with the types 3 and 4 designs. These data, shown in Plate 11, indicated that the structure was slightly more efficient with the different types of designs tested relative to the calculated data furnished in the Tyrone Flood Control Project Design Memorandum No. 6.

Transition Downstream from Westvaco Dam

16. Although the upstream modifications greatly improved flow conditions and reduced cross waves downstream from Westvaco Dam, some surface waves still persisted in a portion of the transition and in curves 6 and 7 (Plates 6 and 7) of the high-velocity channel. This was attributed to the unsymmetrical transition downstream from Westvaco Dam (Plate 4). A curved vertical wall modification (Plate 12) with a 750-ft radius was placed inside the proposed transition between sta 59+46.19 and 57+50 in an attempt to streamline the transition and improve flow conditions immediately downstream of the PA Avenue Bridge. However, this modification resulted in little improvement of flow conditions. It was concluded that modifications inside the transition would result in little improvement in flow conditions; therefore, no further tests were conducted with this type of modification in the transition.

High-Velocity Channel

17. Flow conditions in the Bald Eagle Creek high-velocity channel were generally satisfactory for the full range of discharges tested, including the design discharge of 13,400 cfs (Photos 11-15). The wall heights were adequate to contain design flood conditions, including the surface waves present in curves 6 and 7.

Stilling Basin and Confluence

Original design

18. Unsatisfactory flow conditions were observed in the Bald Eagle

Creek stilling basin and at the Bald Eagle Creek-Little Juniata River confluence (Photo 16, Plate 13) for both flood conditions. During a maximum discharge of 13,400 cfs in Bald Eagle Creek with no flow in the Little Juniata River, fairly good stilling basin action was obtained (Photo 17a), although high exit velocities were measured at the confluence. The curved channel downstream of the stilling basin caused unequal flow distribution in the Bald Eagle exit channel and directed the majority of flow along the left side of the Little Juniata River (Photo 18a). With discharges of 11,000 cfs in Bald Eagle Creek and 29,300 cfs (design discharge) in the Little Juniata River, dissipation of energy in the stilling basin was unsatisfactory due to the effects of high tailwater which caused flow in Bald Eagle Creek to ride over the basin. This resulted in little dissipation of energy before flow entered the Little Juniata River (Photo 17b). Also with design flood conditions in the Little Juniata River, the river flow forced the smaller flow from Bald Eagle Creek against the left bank slope downstream from the confluence (Photo 18b). Velocities measured in this vicinity are shown in Plates 14 and 15. Tailwater elevations used with these tests are shown in Plate 16.

Alternate designs

19. The right wall downstream from the Bald Eagle Creek stilling basin at its confluence with the Little Juniata River was shortened 39.3 ft to sta 9+73.18 in an effort to direct flow from Bald Eagle Creek toward the center of the Little Juniata River. This modification allowed an excessive amount of flow to cross to the right bank with the design discharge in Bald Eagle Creek and no flow in the Little Juniata River as shown in Photo 19a. Little change in flow conditions was observed with the design flow in the Little Juniata River (Photo 19b). The length of the wall was increased 10 ft to sta 9+63.18. This improved flow conditions (Photo 20), but there was still some buildup of flow on the right bank. An additional 5 ft was added to the wall (sta 9+58.18), resulting in a net decrease of 24.3 ft in the length of the original wall. This appeared to be the optimum length of the wall with its original curvature for flood flows in Bald Eagle Creek. With the design discharge in the Little Juniata River, the river flow still forced the discharge from

Bald Eagle Creek against the left slope downstream of the confluence. Flow conditions with this modification are shown in Photo 21.

20. Tests were conducted with modifications to the Bald Eagle stilling basin (Plate 17) in an effort to obtain equal flow distribution in the Bald Eagle exit channel. The top of the end sill was lowered to el 864.0 and 12.5-ft-high flow control vanes were positioned such that the width of the exit channel was divided into three equal parts (Photo 22a). The vanes improved flow distribution in the curved exit channel, but the majority of flow was directed along the left side of the Little Juniata River with the design discharge in Bald Eagle Creek (Photo 23). Very little change was observed in the performance of the stilling basin with the flow control vanes installed (Photo 22).

21. The invert of the Bald Eagle exit channel between sta 10+55.5 and 9+33.88 was lowered to el 860.0 to increase the depth of tailwater, thereby increasing the area for energy dissipation to occur before flow entered the Little Juniata River. Various arrangements of baffle piers along with different heights of end sills were tested throughout the stilling basin and in the curved exit channel with the confluence wall ending at sta 9+58.18. The hydraulic jump was unstable with this modification regardless of baffle arrangements or end sills tested. Thus, no further tests were conducted with this type of modification.

Recommended design

22. Additional tests of various modifications to the Bald Eagle Creek-Little Juniata River confluence walls were conducted in an effort to further improve flow conditions in the Little Juniata River. Performance of the model with several changes in the alignment of the vertical walls downstream from the stilling basin were observed with flood conditions in Bald Eagle Creek and in the Little Juniata River. The radius of the center line of the curve downstream from the stilling basin was increased from 65.21 ft to 70.0 ft in the recommended design (type 28) as shown in Figure 3 and Plate 18. This design provided satisfactory flow conditions downstream of the confluence with both design flood conditions. Although some buildup of flow still occurred along the right bank of the Little Juniata River near sta 132+25 during flood flows in

Figure 3. Looking downstream at the type 28 confluence design and slope modification on the right bank of the Little Juniata River

Bald Eagle Creek, significant improvement in flow conditions at the confluence (Photo 24) was observed relative to the original confluence curvature previously tested. The original stilling basin design was in place during these tests. Very little change was observed in the performance of the stilling basin with the type 28 confluence design, as shown in Photo 25.

23. Flow conditions resulting from numerous combinations of discharges ranging from 2,500 to 13,400 cfs in Bald Eagle Creek, and from 2,500 to 29,300 cfs in the Little Juniata River were observed with the type 28 design. Flow conditions downstream from the confluence were satisfactory for all combinations of discharges. With low flows in Bald Eagle Creek and high discharges in the Little Juniata River, the excessive tailwater caused flow to ride over the stilling basin. This

condition caused some surface waves but was not critical since velocities downstream from the basin were not excessive.

Bank Modification in Little Juniata River

24. Tests were conducted in the Little Juniata River with a modification extending the 1V-on-2H slope upstream to sta 137+19.39 (Figure 3), to determine if this would have any effect on flow conditions in the Little Juniata River. Details of the slope modification with the type 28 confluence design are provided in Plate 18. Test results indicated that the modification had little effect on the general flow conditions throughout the reach of the Little Juniata River reproduced in the model (Photo 26). Velocities measured in this vicinity are shown in Plates 19 and 20.

Bank Protection in Little Juniata River

25. Various plans were tested in the Little Juniata River to determine the optimum riprap and gabion sizes needed for protection of the side slopes and bridge piers. The type 28 confluence design was used during these tests.

Riprap tests

26. The type 1 plan consisted of riprap with an average diameter (D_{50}) of 16 in. and a blanket thickness of 24 in. on the side slopes from sta 137+19.39 to 131+00 (Photo 27). Tests were conducted with flow conditions resulting from numerous combinations of discharges ranging from 2,500 to 13,400 cfs in Bald Eagle Creek and from 2,500 to 29,300 cfs in the Little Juniata River. These tests were conducted for a minimum of 5 hr (prototype) for each flow condition and for 15 hr (prototype) each with design flow conditions in Bald Eagle Creek and in the Little Juniata River. No failure was observed during these tests.

27. The size of the riprap was reduced to an average diameter (D_{50}) of 12 in. with a blanket thickness of 18 in. (type 2, Photo 28). Failure occurred along the right slope after a 10-hr test with a discharge

of 13,400 cfs in Bald Eagle Creek and no flow in the Little Juniata River (Photo 29). Failure also occurred along the left slope after a 15-hr test with a discharge of 11,000 cfs in Bald Eagle Creek and 29,300 cfs in the Little Juniata River (Photo 30).

28. The riprap was increased to 16 in. (D_{50}) with a blanket thickness of 24 in. from sta 133+60 to 131+00 with the remainder of the slopes protected with 12-in. (D_{50}) riprap (type 3). Tests were conducted using various flow conditions and each test duration was equivalent to a minimum of 5 hr. The type 3 riprap plan was also tested with design flood conditions in Bald Eagle Creek and in the Little Juniata River with each test lasting 15 hr. No failure in the riprap was observed along the left slope after the tests. However, the 16-in. (D_{50}) riprap that was stable in the first series of tests became unstable along the right slope just downstream of the piers after this series of tests.

29. The riprap was increased to 18 in. (D_{50}) with a blanket thickness of 27 in. along the right slope between sta 133+00 and 131+25. The remainder of the slopes were protected with 16-in. (D_{50}) and 12-in. (D_{50}) riprap as shown in Plate 21. This riprap plan was designated the type 4 protection plan. No failure of the riprap was observed after this plan was subjected to the same series of tests as used in the type 3 riprap plan tests. From the results of these tests, the type 4 riprap plan was recommended for the prototype, if riprap is used. The gradation of the riprap tested in the model is shown in Plates 22-24.

Gabion tests

30. Gabions, 12 ft by 3 ft by 1 ft, were tested on the side slopes to determine the optimum gabion protection plan for the Little Juniata River. Due to the time element required in making the gabions, only enough gabions to make a large test section were constructed. Tests were initially conducted with the gabions on the right slope between sta 133+60 and 131+00 (Photo 31), the area where the 18-in. (D_{50}) riprap was required. Tests were conducted with design flood conditions on Bald Eagle Creek and on the Little Juniata River for 20 hr (prototype) each. Additional tests were conducted with various other flow conditions for 5 hr (prototype) each. No failure was observed in the gabion test

section after these tests. Tests were then conducted with the gabions placed on the left slope between sta 133+60 and 131+00 (Photo 31). Again, no failure was found in the gabion test section for the same flow conditions that were used in the first series of gabion tests. The gabions were not wired together in either test section. The recommended gabion design is shown in Plate 25.

31. Gabions were not tested on the side slopes where the 12-in. (D_{50}) riprap was required, since no failure in the gabion plan occurred in the areas where the larger riprap was required. The gabions used in these tests represent the minimum thickness (12 in.) that the Baltimore District had indicated would be considered practical for the prototype; therefore, gabions less than 12 in. thick were not tested in the model.

PART IV: DISCUSSION OF RESULTS

32. Tests to determine the adequacy of channel improvements on both Bald Eagle Creek and the Little Juniata River indicated that the original design with certain modifications would effectively contain design flood conditions occurring in either channel.

33. In Bald Eagle Creek, unsymmetrical approach conditions to Westvaco Dam resulted in unequal flow distribution across the dam which caused unsatisfactory flow conditions in the transition section immediately downstream. With the design discharge of 13,400 cfs, a considerable buildup of flow occurred along the left abutment of the dam which caused a large cross wave to develop in the transition section. Drawdown in the water surface at the right abutment of Westvaco Dam also produced a cross wave in the transition section immediately downstream.

34. A slope modification on the left bank slope upstream of Westvaco Dam significantly improved approach conditions to the dam. This modification reduced the buildup of flow along the left abutment considerably and decreased the height of cross waves that developed in the transition.

35. A 25-ft-radius curved wing wall on the right abutment of Westvaco Dam reduced the drawdown in the water surface, thereby improving flow conditions in the transition section. However, there was some question about the construction of this wall because of a parking lot in this area and the right transition wall was extended upstream of Westvaco Dam to determine its effects on flow conditions in this vicinity. Flow conditions were satisfactory upstream of the dam with improved flow distribution across the dam. A reduction in cross-wave heights was observed in the transition section. Although this reduction was not as significant as was observed with the curved wing wall placed on the right abutment, either of the modifications should be sufficient to eliminate overtopping of the walls downstream from the dam.

36. Calibration data obtained for Westvaco Dam with the original design showed the structure to be slightly more efficient than anticipated.

37. The unsymmetrical transition design immediately downstream of Westvaco Dam caused surface waves to develop in the downstream portion of the transition and in curves 6 and 7 in the high-velocity channel. These surface waves were independent of modifications in the upstream approach channel to Westvaco Dam. Attempts to further streamline the transition within the right-of-way constraints resulted in little improvement in flow conditions. Thus, it was concluded that modifications of this type in the transition would result in little improvement in reducing the heights of surface waves. Wall heights adequate to contain design flood conditions and surface waves that were present as a result of the unsymmetrical transition will be provided in curves 6 and 7. Flow conditions in the remainder of Bald Eagle Creek high-velocity channel were satisfactory for all discharges tested.

38. Unsatisfactory flow conditions were observed in the Bald Eagle stilling basin and at its confluence with the Little Juniata River. High exit velocities at the confluence were present with the design discharge in Bald Eagle Creek and no flow in the Little Juniata River. Unequal flow distribution in the Bald Eagle Creek exit channel was also observed with the majority of flow being directed along the left slope of the Little Juniata River. With the design discharge in the Little Juniata River, excessive tailwater depths were present in the stilling basin causing the flow in Bald Eagle to ride over the basin, resulting in little dissipation of energy before entering the Little Juniata River.

39. By reducing the length of the confluence wall between Bald Eagle Creek and the Little Juniata River by 24.3 ft, and increasing the radius of the center line of the curved channel downstream from the Bald Eagle Creek stilling basin to 70 ft, flow conditions were improved downstream from the confluence. Although maximum velocities in this area were not greatly reduced, more flow was directed along the center of the channel, thus reducing scour potential along the banks and bridge piers.

40. The excessive tailwater that occurred with high discharges in the Little Juniata River and relatively low discharges in Bald Eagle Creek caused flow to ride along the water surface over the stilling basin. Although several modifications to the basin and area downstream

were tested in an effort to improve this condition, no feasible solution was found. Raising the apron of the stilling basin would eliminate the problem with low flows and high tailwaters, but then the basin would not perform satisfactorily with higher flows and/or lower tailwaters. Since downstream velocities resulting from the overriding flow were not critical, it was concluded that the original design basin should be used.

41. Flow conditions in the Little Juniata River upstream from the confluence were satisfactory for all discharges tested. The right slope was extended upstream approximately 184 ft with no effects in the general flow conditions in this area.

42. Either riprap or gabions could be used for protection of the bank slopes in the Little Juniata River and the bridge piers downstream from the confluence. If riprap is used, a plan consisting of various sizes of stone was developed. If gabions are used, a thickness of only 12 in. will provide adequate protection against both design flood conditions.

Table 1

Water-Surface Elevations

Type 1 (Original) Design
Bald Eagle Creek, Discharge 13,400 cfs
Little Juniata River, Discharge 0 cfs

Station	Elevation Left Side	Elevation Right Side
Bald Eagle Creek		
1+50	925.7	925.8
0+50	924.5	926
0+25	924.1	926.1
0+00 = 59+46.19	924.9	926.5
59+42.68	925.3	924.5
59+20	918.5	915.9
58+50	916.5	912.8
58+00	914.8	911.0
57+60		917.8
57+50	912.9	
56+69	917.8	
56+55		910
56+15	910	
56+05		915.5
55+85	912.5	
55+47		908.9
55+33	915.9	
55+00		912.2
54+85	907.5	
54+30		908.1
54+20	912.3	
53+75	909.3	
53+50		912.5
53+15	913.6	907.7
52+77		910.8
52+50	911.3	
52+05	915.2	
52+00		908.4
51+65	911.1	
51+55		911.1
51+00	913.7	
50+90		908.2
50+60		911.1
50+50	910.8	
50+00	912.2	908.2
49+45	909.4	
49+42		910.3
49+17	911.7	
49+05		907.8
48+45	909.2	909.5
48+00	911.3	907.6
47+55	909.4	907.4
47+00	909.5	907.2
46+60		909.3
46+50	908	
46+05		907.8
45+85	909.1	
45+55	907.1	908.6
45+15	909.6	
45+10		907.5
44+65	907.6	
44+55		909.1
44+10		908
44+05	909	
43+75		910
43+68	907.3	
43+20	909.1	
43+10		908.4
42+80	907	

(Continued)

Note: Sides of channel are referenced to downstream direction.

Table 1 (Continued)

Station	Elevation Left Side	Elevation Right Side	Station	Elevation Left Side	Elevation Right Side
Bald Eagle Creek (Continued)			29+00	899.2	898.1
			28+65	900.3	898.3
42+75		909.7	28+25	900.2	897.5
42+35	908.2		27+75		897.5
42+25		908.5	27+25		896.5
42+00	907.4		27+10	899.5	
41+90		909.6	26+75	898.4	896.8
41+50	907.7	908	26+40	898.6	896.1
41+15		909	25+50	896.2	895.8
40+90	906.1		25+00	895.7	894.4
40+50	907.2	906.8	24+10	894	895.6
40+05	905.9		23+65	894.9	895.3
39+95		907.1	22+85	893.7	896.7
39+60	906.7	905.2	22+35	894	895.5
39+25		906.8	22+00		895.9
39+00	905		21+70	892.3	
38+55	906.5		21+15	893.2	894.1
38+50		904.1	20+25	891.2	892.4
38+05	905.1	905.3	19+75	891.4	890.7
37+60	905.2	905	19+29	890	890.4
37+10	905.2	904.5	18+50	890.1	889.6
36+60	905.6		18+00	889.1	889.5
36+50		902.9	17+50	889.1	888.6
36+00	903.6	903.1	16+50	887.4	887.8
35+45	903.4	901.6	15+50	886.8	886.7
35+08		902.8	15+00	886	886.7
34+80	901.7		14+25	885.4	885.6
34+30	901.7	901.1	13+65	885	887.4
33+80	900.6	901.2	13+32	884.5	887.2
33+31	901.1		12+80.96	884	884.6
33+20		900.1	12+35	883.4	883.4
32+62	899.8	900.5	11+75	882	882.6
32+00	899.7	899.2	11+56.5	879.4	878.5
31+40	898.7	899.7	11+18	872.4	872.4
31+00	899.2	899.1	11+15.5	869.5	869.5
30+32	898.6	898.9			
29+50	899.4	897.9			

(Continued)

Table 1 (Concluded)

Station	Elevation Left Side	Elevation Right Side
Bald Eagle Creek (Continued)		
10+65	882.5	883.1
10+28		879.8
10+15	870.8	
9+95		884.7
9+78		878.9
9+65	875	
9+50		884.3
9+33.88	876.7	876.7

Station	Elevation Left Side	Elevation Right Side
Little Juniata River		
138+76.44	877.6	877.6
137+25	876.6	877
135+55	877	877
134+25		877.7
133+25	876.6	877
132+25	877.6	877
131+00	877.5	877.5

(Sheet 3 of 3)

Table 2

Water-Surface Elevations

Type 1 (Original) Design
Bald Eagle Creek, Discharge 11,000 cfs
Little Juniata River, Discharge 29,300 cfs

Station	Elevation	
	Left Side	Right Side
Bald Eagle Creek		
1+50	924.5	924.5
1+00	924.1	924.7
0+50	923.5	924.9
0+00 = 59+46.19	924	924
59+42.68	923.6	921.3
59+23.5	918	914
59+03		914.1
58+88		913.4
58+50	915	
58+00	914.5	
57+70		909.1
57+46	911.6	916
57+00	910.5	910.5
56+82	912.3	912.3
56+43	915.2	908.4
56+00	908	
55+80		912
55+65	910	
55+37	907	
55+08	913	906.4
54+65	906	
54+55		908.9
53+70	910.6	
53+57		905.1
53+25	908.8	909.7
52+93	910.3	
52+75	909.6	907.3
52+45	913.1	
52+35		906.1
52+00	909.2	908.6
51+85	910.9	
51+55	910.3	
51+40		906.8
51+33	911.2	
51+00	908.8	
50+95		908
50+65	910.7	
50+50		906
50+12		908
50+00	908.1	
49+58	910.6	
49+45		905.8
49+10	907.7	908.1
48+75	909	
48+50		905.7
48+40	909.6	
48+15		907.7
48+05	906.8	
47+70	908.3	
47+50		905.9
47+40	908.5	
47+00	906.2	
46+95		907.4
46+60	907.8	905.9
46+00	906	907.1
45+55	906.9	905.6
45+10	905.7	906.4
44+75	906.5	
44+55		906.1

(Continued)

Note: Sides of channel are referenced to downstream direction.

Table 2 (Continued)

Station	Elevation Left Side	Elevation Right Side
Bald Eagle Creek (Continued)		
44+25	905.9	907.1
43+85	906.5	906.8
43+50		907.8
43+33	905.9	
43+00	906.6	906.8
42+55	905.1	907.5
42+20	906.3	
42+10		906.7
41+85	905.6	
41+72		907.1
41+20	905.6	906.2
40+91		906.7
40+75	904.4	
40+45	905.4	905.2
40+00	904.2	905.2
39+60	904.8	
39+50		903.8
39+25		904.7
39+00	903.6	
38+53	904.3	902.7
38+05	903.8	903.3
37+65		902.6
37+46	904.5	902.7
37+36		902.4
37+18		902.8
37+10	903.7	
36+70	903.8	
36+40		901.6
36+00	902.4	901.4
35+50	901.7	900.5
35+25		900.8
34+95	900.3	
34+50	900.3	
34+00		900
33+90	899.4	
33+25	899.3	898.9
32+75	898.6	899.1
32+30		898.2
32+00	898.4	
31+50	897.5	898.4
31+00	898	897.7
30+32	897.2	897.7
30+00		896.9
29+50	897.8	897.1
28+65	899.1	896.7
28+50		896
28+25	898.3	896.5
27+42	898.1	895.4
27+15		895.7
26+85	897.5	894.8
26+50	897.2	
26+45		894.8
25+50	894.8	894.4
25+10		893.3
25+05	894.6	
24+25	893	894
23+77	893.7	893.7
23+25	892.8	894.8
22+85		894.9
22+60	893.1	894.3
22+10	891.9	894.3
21+85	892.3	894.3
21+65	891.3	
21+50		893.6
21+19	891.8	
21+00		892.7
20+89	890.7	
20+60	890.7	891.8
20+35	890.2	891.6
19+80	889.8	889.8
18+50	888.6	888.4
17+50	887.4	887.4

(Continued)

Table 2 (Concluded)

Station	Elevation Left Side	Elevation Right Side	Station	Elevation Left Side	Elevation Right Side
Bald Eagle Creek (Continued)			Little Juniata River		
16+50	886	886.1	138+76.44	890	890
15+50	885.2	885.3	136+75	889	889
14+50	884.4	884.2	135+65	888.5	887
14+07	884.3	884.8	133+60	888.4	889
13+75	883.6	885.8	132+25	888.6	889.8
13+20.96	883.4	885.7	131+00	889	889
12+80.96	882.7	883			
12+35	882	882.8			
11+75	887	881.2			
11+56.5	886.4	879			
11+15.5	886.6	890			
10+65	886.8	889.2			
10+30	887	890.3			
9+78.18	887.4	890			
9+55	888	889			
9+33.88	887.5	890			

Table 3

Water-Surface Elevations

Type 3 Design
Bald Eagle Creek, Discharge 13,400 cfs

Station	Elevation Left Side	Elevation Right Side
1+50	925	925.2
1+00	925.2	925.4
0+50	925.1	925.5
0+25	925.1	925.6
0+00 =		
59+46.19	924.9	924.2
59+42.68	923.8	922.5
59+20	916	914.4
59+00	915	913.9
58+50	914	912.9
58+00	913.8	910
57+75		910.3
57+39		914.9
57+25	913.7	
56+88	912	910
56+59		913.5
56+46	914.4	
56+36		911
56+12		912.5
55+93	909	
55+61	914	911.8
55+25	908.4	
55+14		908
54+92	911.3	
54+75		911
54+42.50	907.5	908

Note: Sides of channel are referenced to downstream direction.

Table 4

Water-Surface Elevations

Type 4 Design
Bald Eagle Creek, Discharge 13,400 cfs

Station	Elevation Left Side	Elevation Right Side
1+00	925.2	925.2
0+50	925	925
0+25	924.8	925
0+00 = 59+46.19	924	923.7
59+42.68	923.8	923
59+26	916.6	916.6
59+20	915.5	915.5
58+50	913.5	913
57+77.5	912	911
57+38	915.5	
57+34.5		914
56+89.25		910
56+85	911.8	
56+58		915.5
56+53.8	913	
56+05.25		910.4
55+94.25	910.4	
55+63.5	913	911
55+28.25	908	
55+09.5		908.5
54+91.25	912	
54+81.57		910.2
54+50		908
54+42	908.1	

Note: Sides of channel are referenced to downstream direction.

Photo 1. Dry bed showing unsymmetrical approach conditions to Westvaco Dam

Photo 2. Looking upstream at the left side of Westvaco Dam showing a buildup of flow along left wall; discharge 13,400 cfs

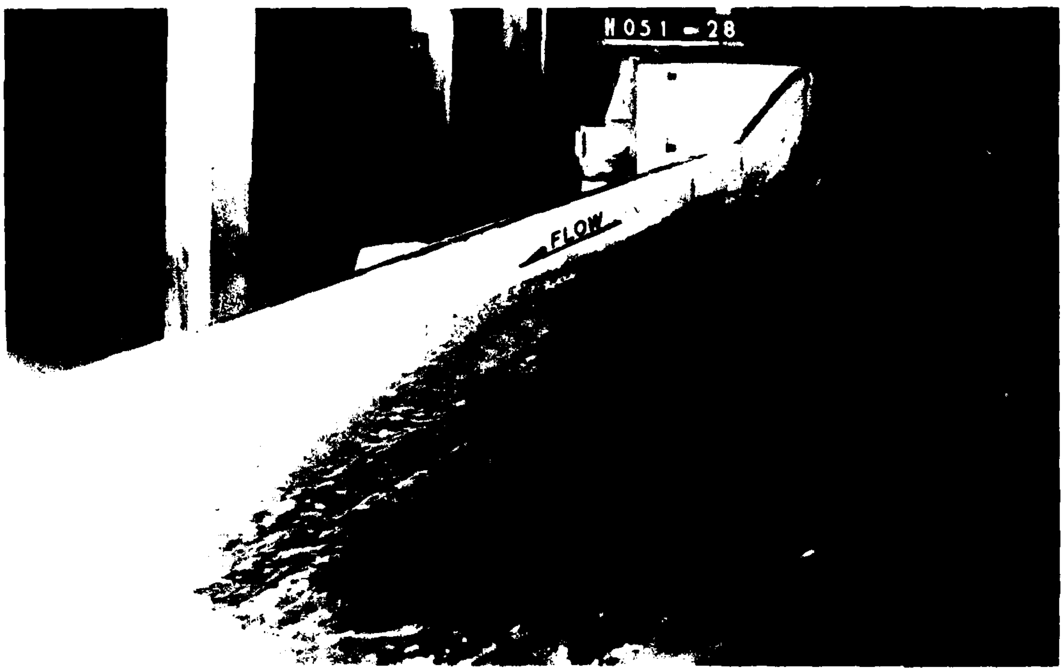


Photo 3. Looking upstream at the right side of Westvaco Dam showing the drawdown in the water surface at the right abutment; discharge 13,400 cfs

a. Discharge 11,000 cfs

b. Discharge 13,400 cfs

Photo 4. Looking downstream at flow conditions upstream of Westvaco Dam with confetti illustrating surface flow patterns; time exposure 5 sec (prototype)

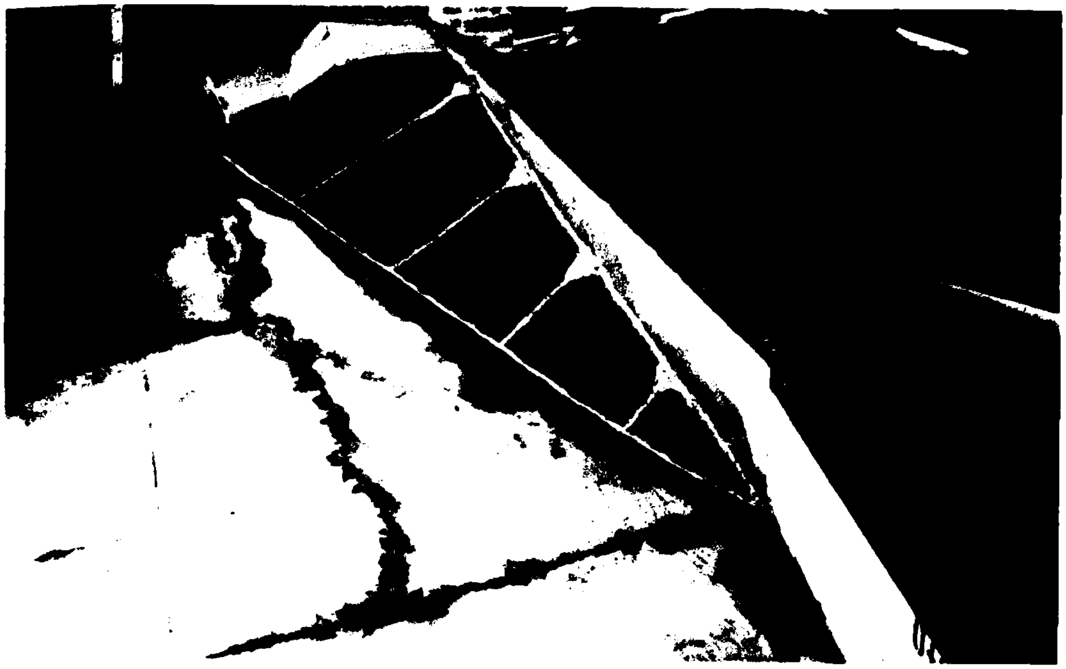


Photo 5. Looking upstream at the IV-on-2.5H tapering slope modification (type 2) on the left side upstream of Westvaco Dam

Photo 6. Looking upstream at flow conditions along left side of Westvaco Dam with the type 2 slope modification installed upstream of the dam; discharge 13,400 cfs

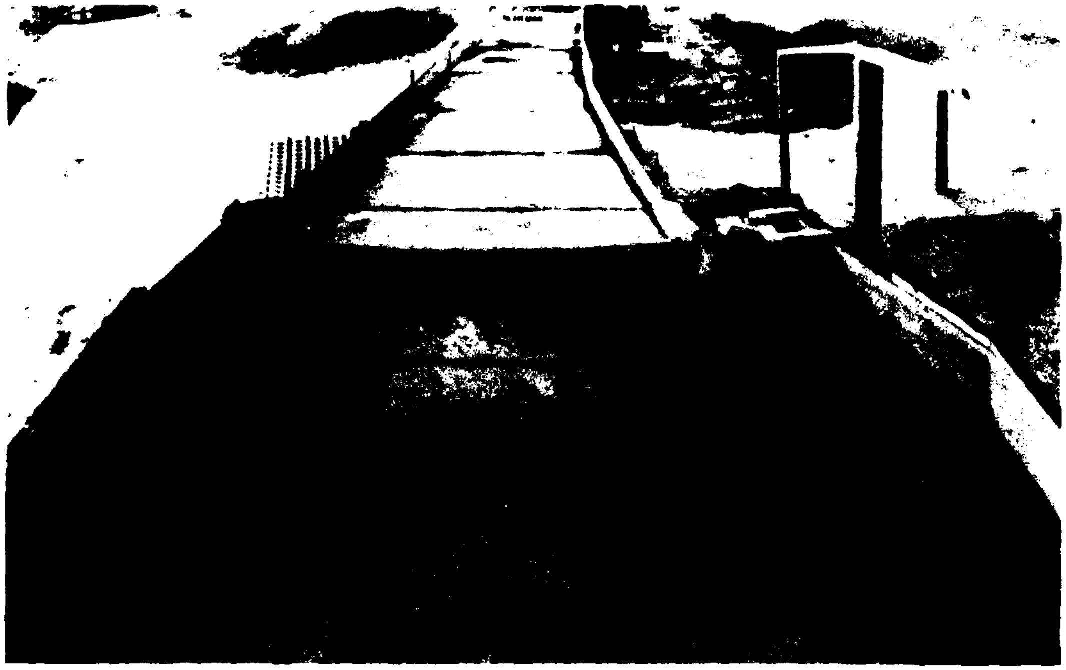
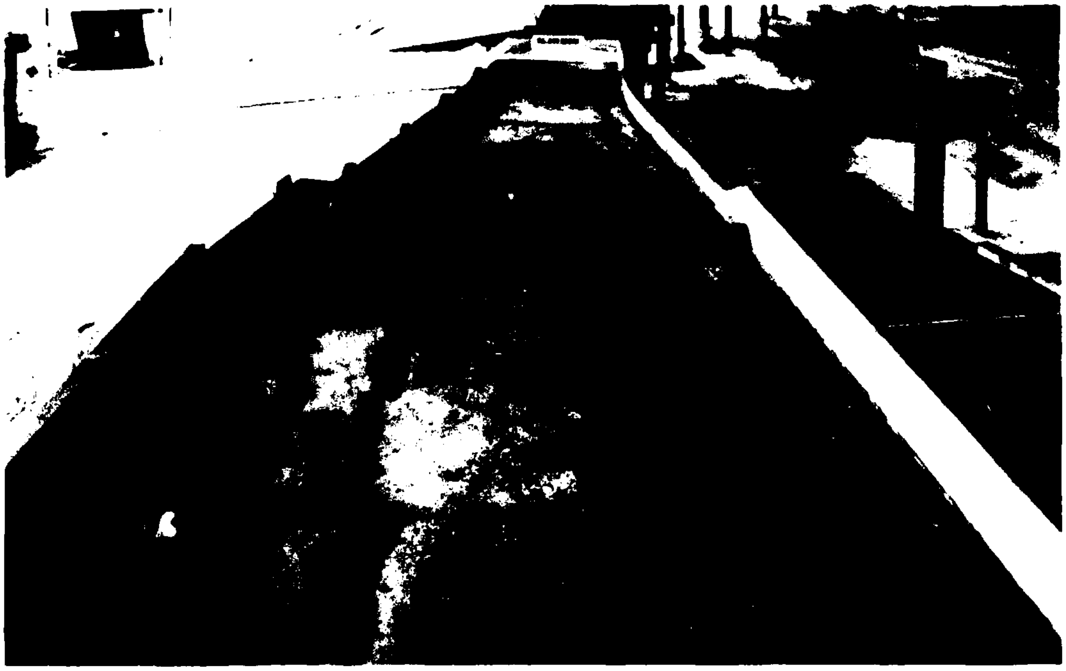


Photo 7. Looking downstream at the type 3 curved wing wall on the right abutment of Westvaco Dam

Photo 8. Looking upstream at flow conditions along right wall of Westvaco Dam with the type 3 curved wing wall on the right abutment; discharge 13,400 cfs

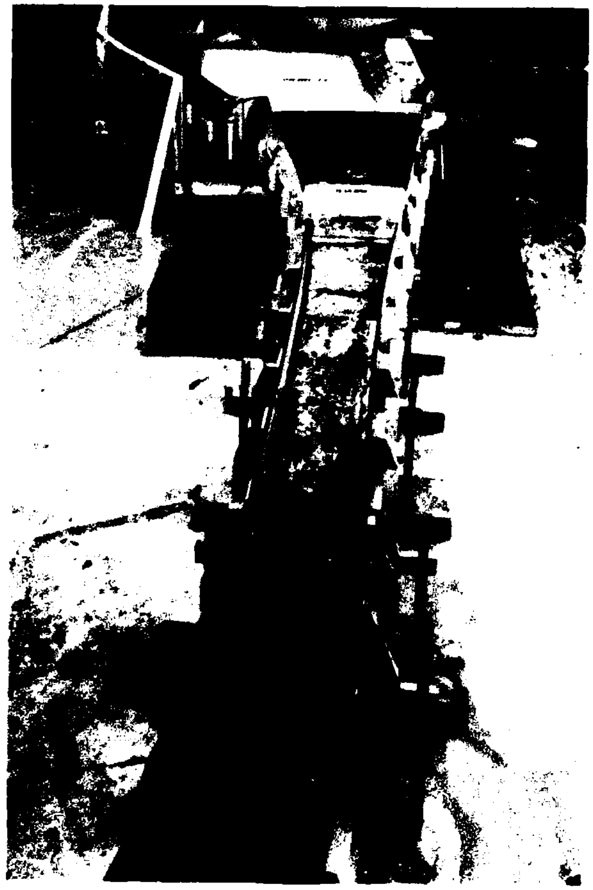
Photo 9. Looking downstream at flow conditions upstream of Westvaco Dam with the type 2 slope modification and the type 3 curved wing wall installed. Confetti illustrates surface flow patterns; discharge 13,400 cfs, time exposure 5 sec (prototype)



a. Dry bed

b. Discharge 13,400 cfs, confetti illustrates surface flow patterns; time exposure 5 sec (prototype)

Photo 10. Looking downstream at the type 4 vertical wall modification on the right abutment of Westvaco Dam with the type 2 slope modification on the left side

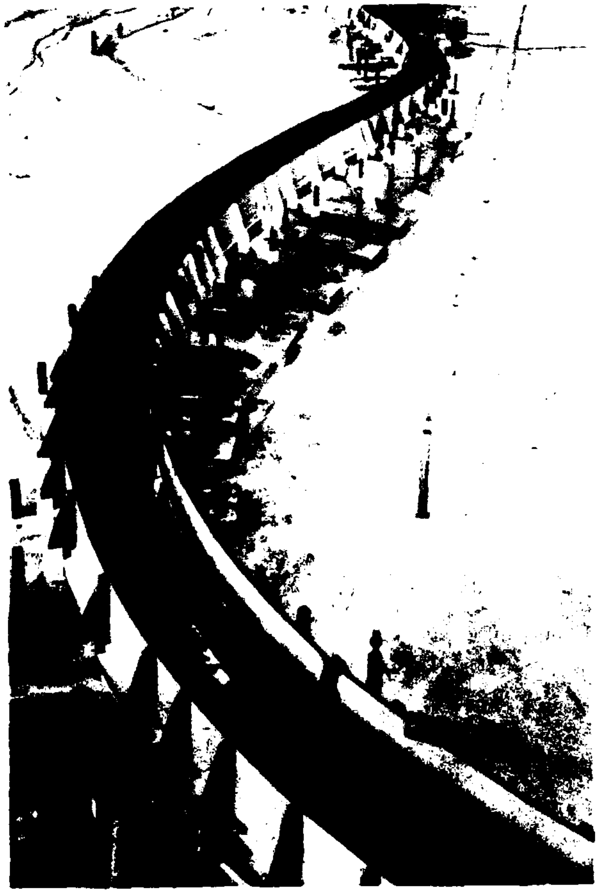


a. Dry bed

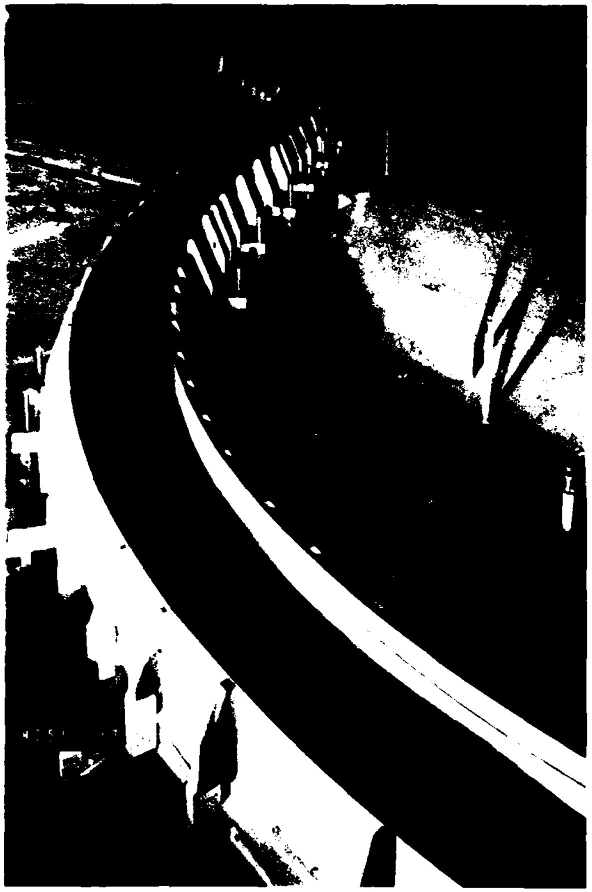
b. Discharge 11,000 cfs

c. Discharge 13,400 cfs

Photo 11. Looking upstream from sta 54+00 showing transition downstream of Wesvaco Dam. Black lines inside of channel walls represent proposed wall heights



a. Dry bed



b. Discharge 11,000 cfs

c. Discharge 13,400 cfs

Photo 12. Looking downstream in Bald Eagle Creek between sta 52+25 and 42+00. Black lines inside of channel walls represent proposed wall heights

a. Dry bed

b. Discharge 11,000 cfs

c. Discharge 13,400 cfs

Photo 13. Looking downstream in Bald Eagle Creek between sta 42+00 and 29+00. Black lines inside of channel walls represent proposed wall heights

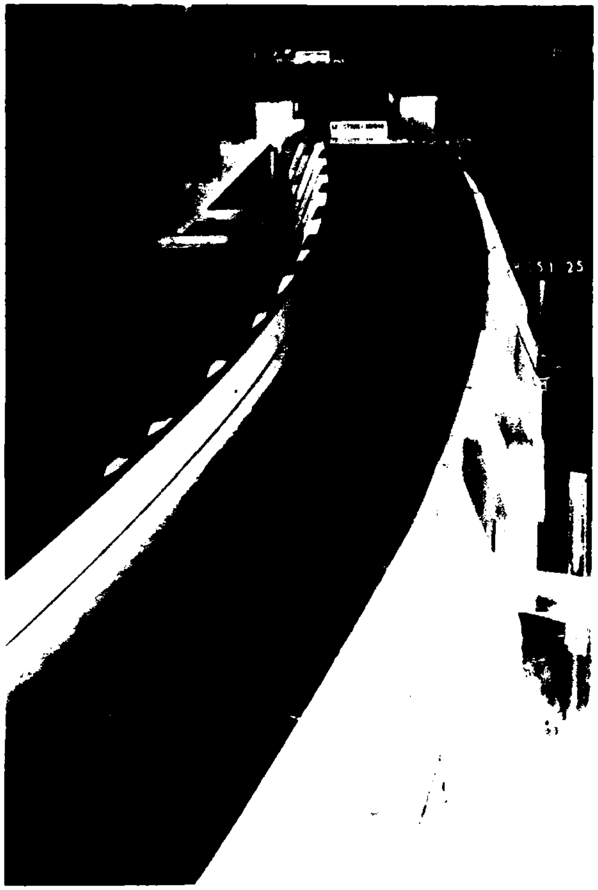
a. Dry bed

b. Discharge 11,000 cfs

c. Discharge 13,400 cfs

Photo 14. Looking downstream in Bald Eagle Creek between sta 29+00 and 20+50. Black lines inside of channel walls represent proposed wall heights

a. Dry bed



b. Discharge 11,000 cfs

c. Discharge 13,400 cfs

Photo 15. Looking downstream in Bald Eagle Creek between sta 23+00 and 12+00. Black lines inside of channel walls represent proposed wall heights

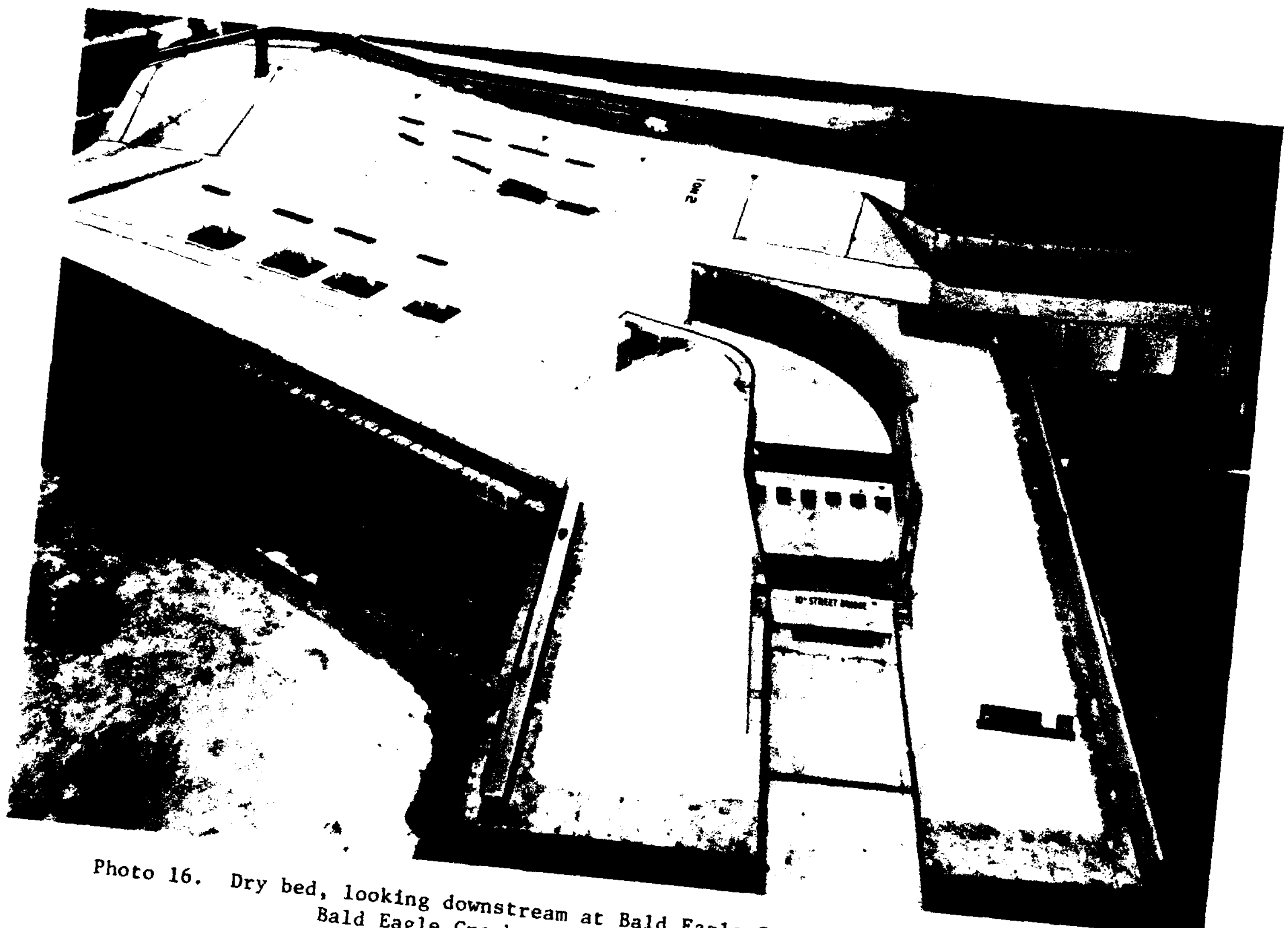
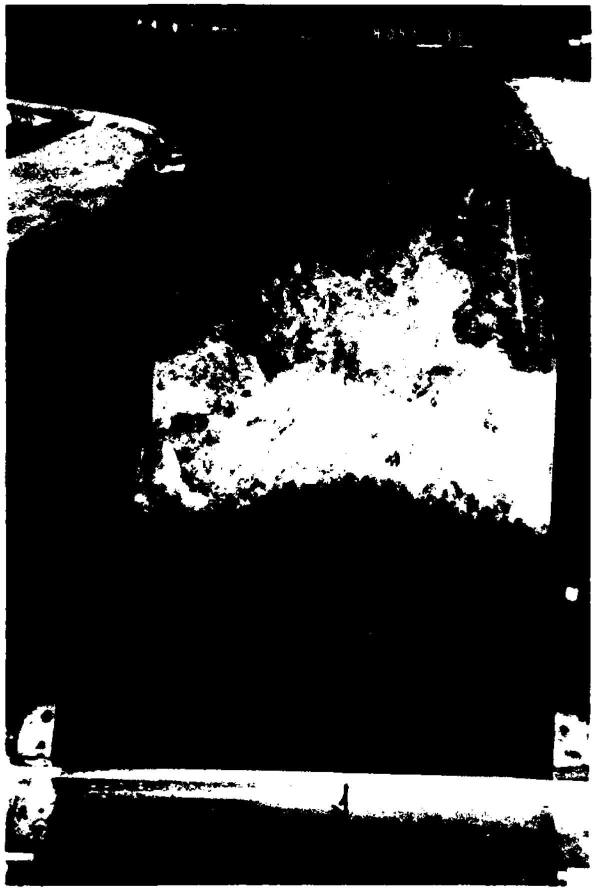


Photo 16. Dry bed, looking downstream at Bald Eagle Creek stilling basin and the Bald Eagle Creek-Little Juniata River confluence



a. Discharge 13,400 cfs, TW el 877.78 (sta 131+00, Little Juniata River)

b. Discharge 11,000 cfs, TW el 889.18 (sta 131+00, Little Juniata River)

Photo 17. Looking downstream in the Bald Eagle Creek stilling basin (type 1)

Photo 18. Looking downstream at flow conditions at the confluence with the type 1 (original) design confluence. Confetti illustrates surface flow patterns; exposure time 5 sec (prototype)

Photo 19. Looking downstream at flow conditions at the confluence with confluence wall ending at sta 9+73.18. Confetti illustrates surface flow patterns. Exposure time 5 sec (prototype)

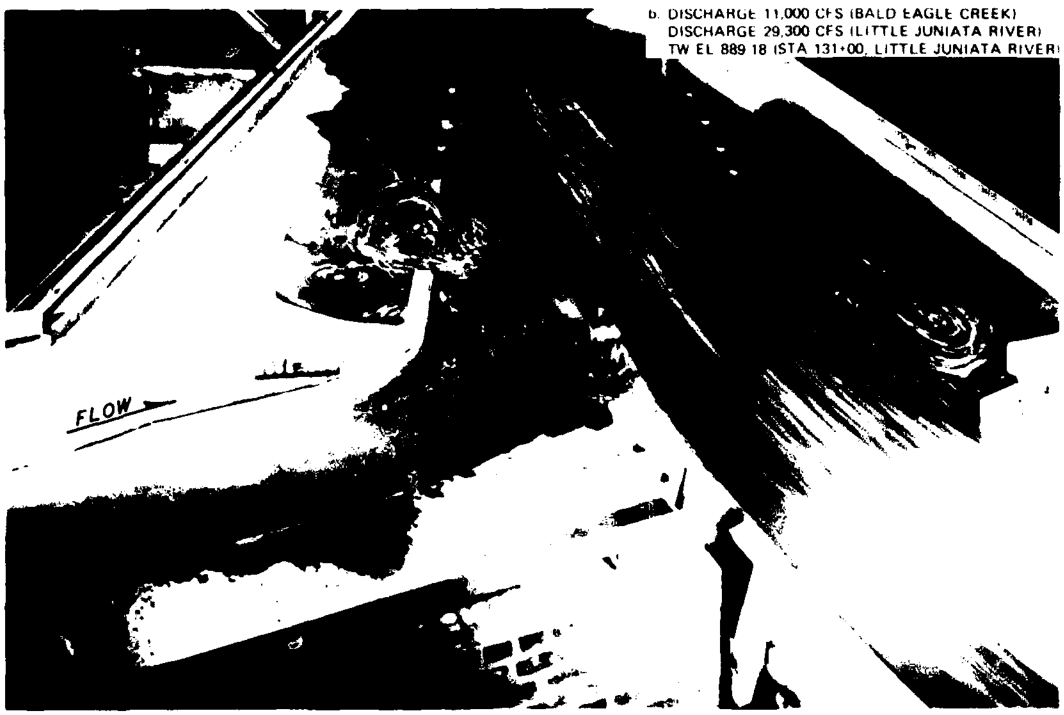


Photo 20. Looking downstream at flow conditions at the confluence with the confluence wall ending at sta 9+63.18. Confetti illustrates surface flow pattern. Exposure time 5 sec (prototype)

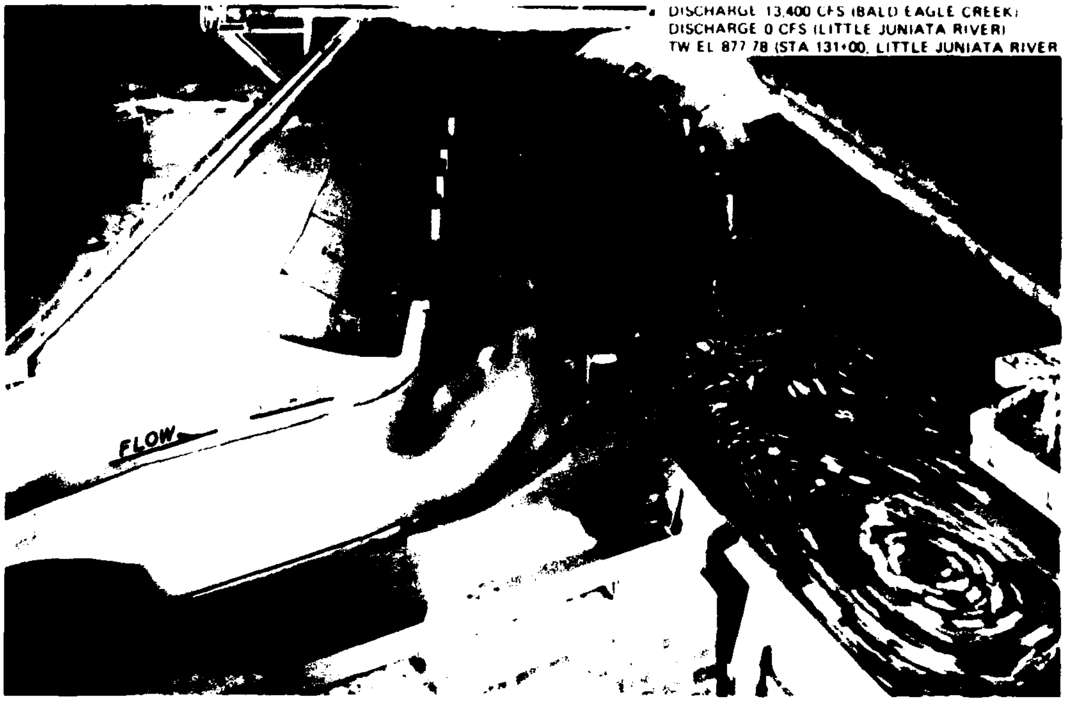
Photo 21. Looking downstream at flow conditions at the confluence with the confluence wall ending at sta 9+58.18. Confetti illustrates surface flow patterns. Exposure time 5 sec (prototype)

a. Dry bed

b. Discharge 13,400 cfs, TW el 877.78
(sta 131+00, Little Juniata River)

c. Discharge 11,000 cfs, TW el 889.18
(sta 131+00, Little Juniata River)

Photo 22. Looking downstream at the Bald Eagle Creek stilling basin with two flow control vanes between sta 10+50.93 and 9+90.18, end sill elevation 864.60, and confluence wall ending at sta 9+58.18



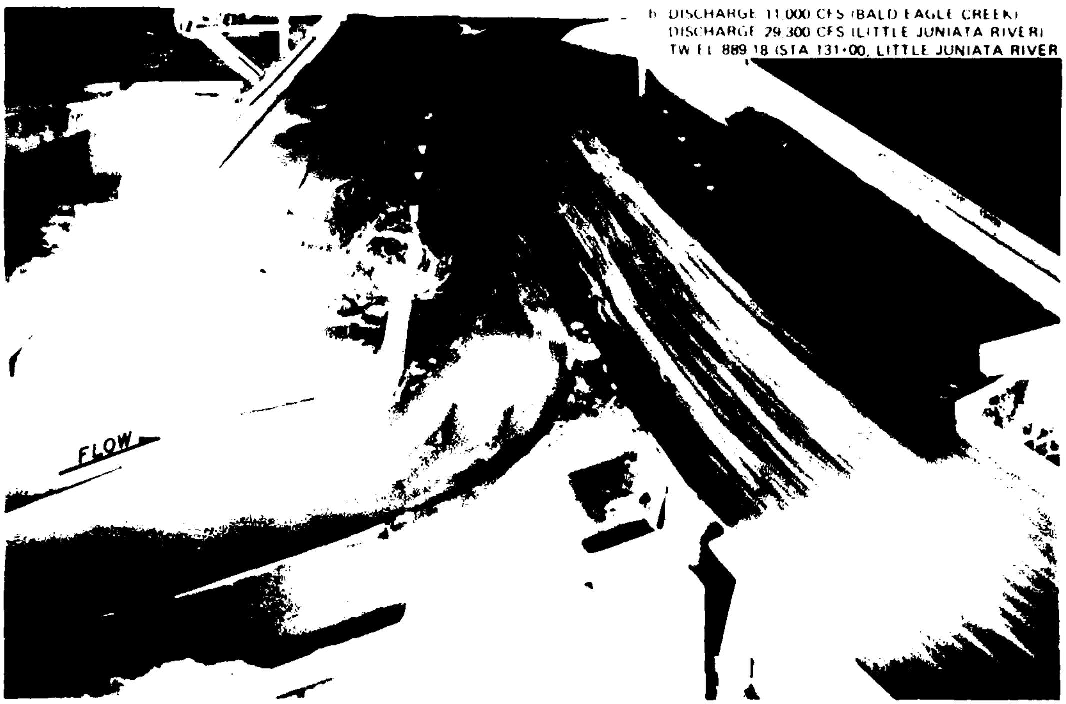


Photo 23. Looking downstream at flow conditions at the confluence with the confluence wall ending at sta 9+58.18, end sill elevation 864.60, and two flow control vanes in the exit channel. Confetti illustrates surface flow patterns. Time exposure 5 sec (prototype)

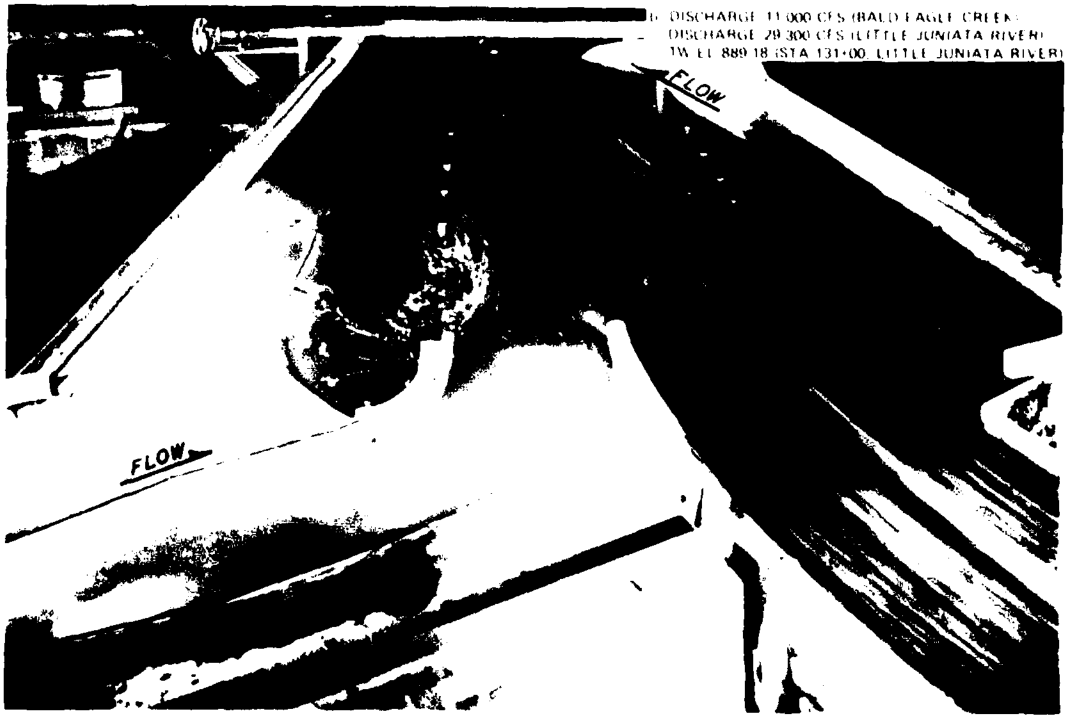


Photo 24. Looking downstream at flow conditions at the confluence with the type 28 confluence design installed. Confetti illustrates surface flow patterns. Time exposure 5 sec (prototype)

a. Discharge 13,400 cfs, TW el 877.78 (sta 131+00, Little Juniata River)

b. Discharge 11,000 cfs, TW el 889.18 (sta 131+00, Little Juniata River)

Photo 25. Looking downstream at flow conditions in Bald Eagle Creek stilling basin with type 28 confluence design

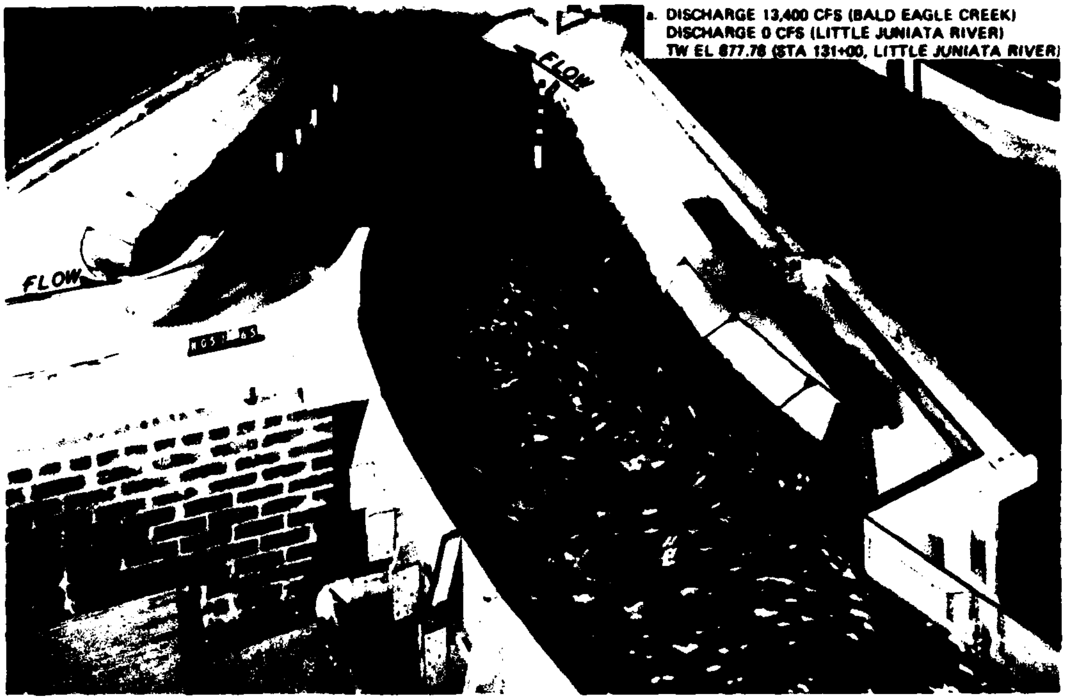


Photo 26. Looking downstream at flow conditions at the confluence with the type 28 confluence design and slope modification on the Little River between sta 135+35 and 137+19.39. Confetti illustrates surface flow patterns. Time exposure 5 sec (prototype)

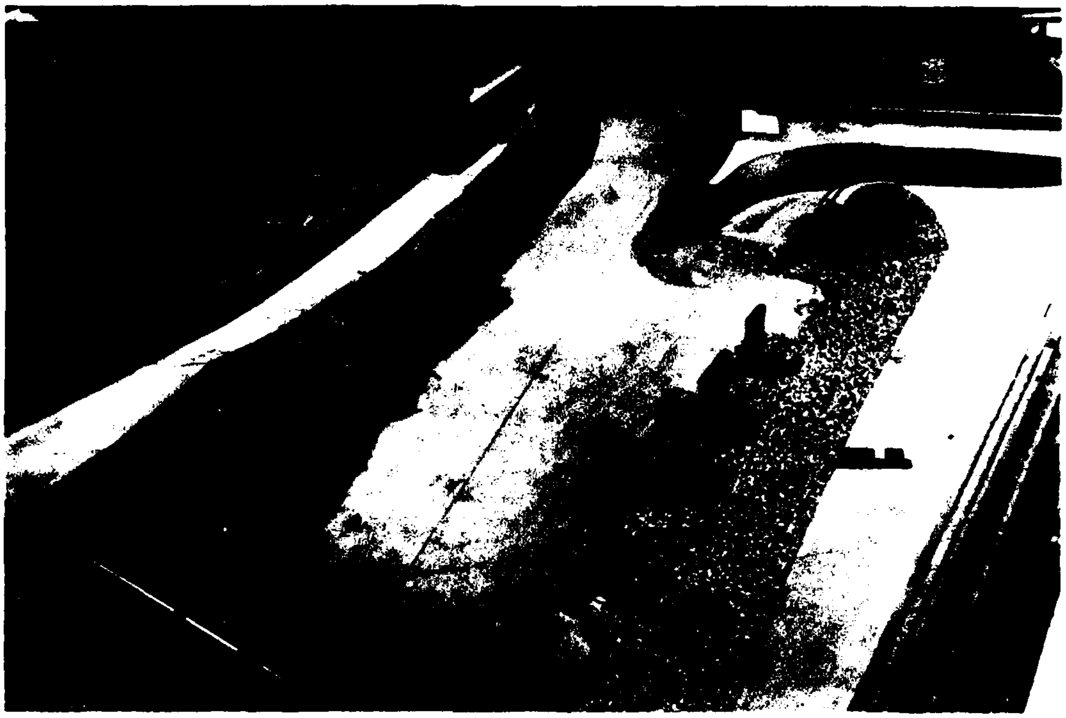


Photo 27. Looking upstream at the type 1 riprap plan

Photo 28. Looking upstream at the type 2 riprap plan

Photo 29. Failure in the type 2 riprap plan on right slope (looking downstream) after a 10-hr (prototype) test with 13,400-cfs discharge in Bald Eagle Creek and no flow in the Little Juniata River; TW el 877.78 (sta 131+00, Little Juniata River)

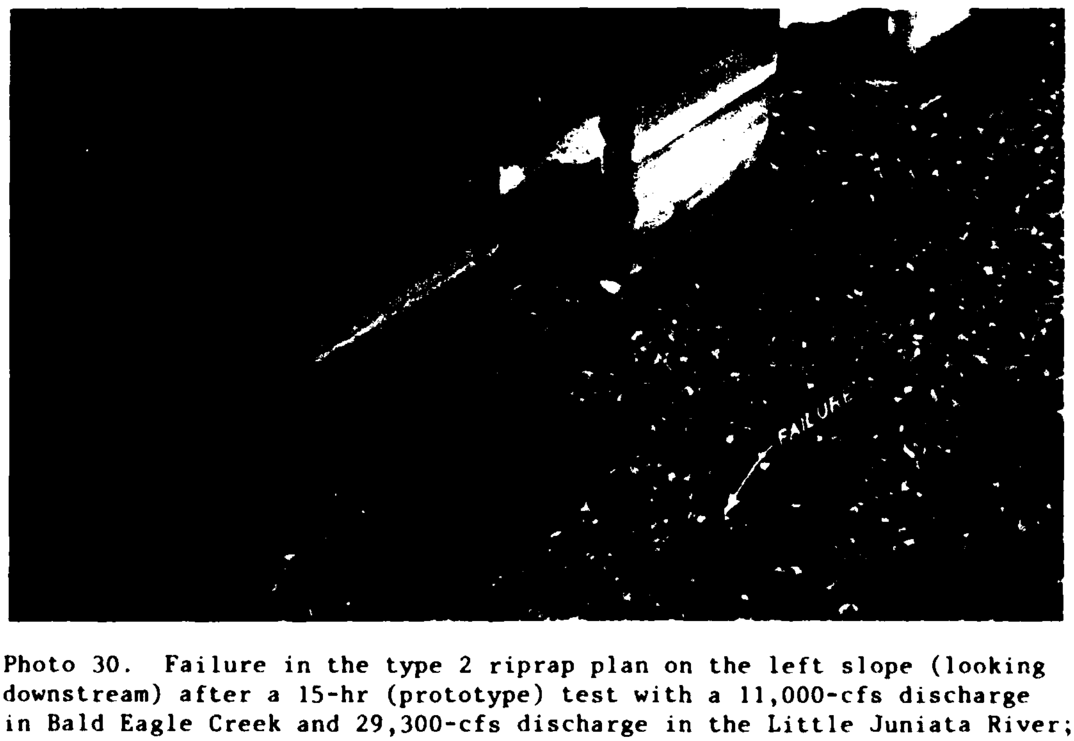
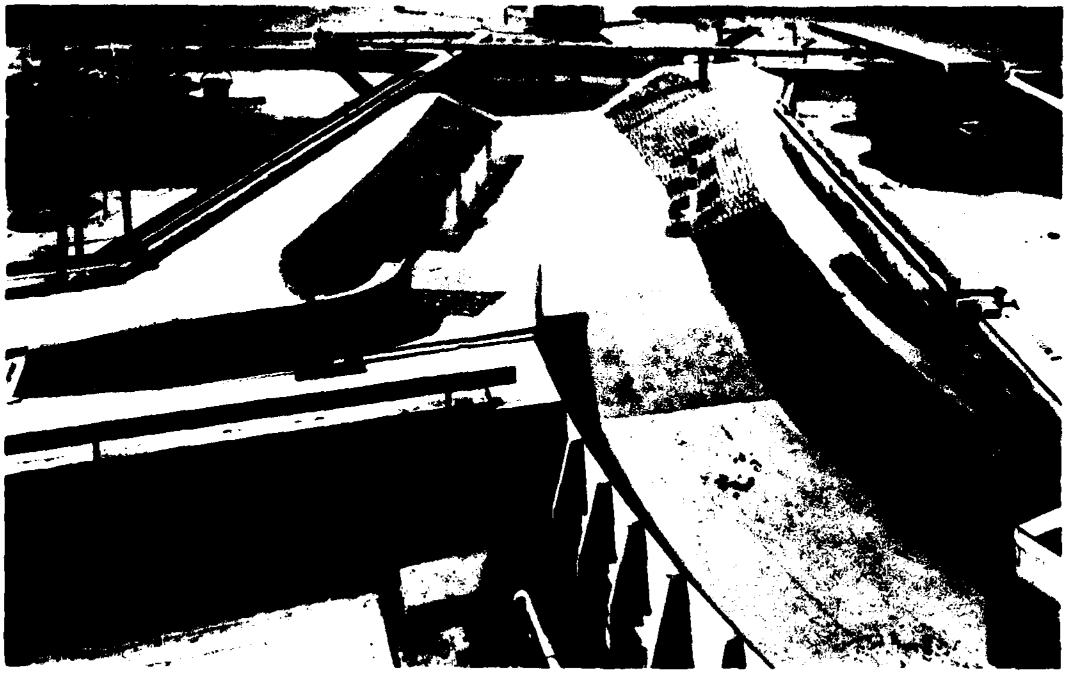


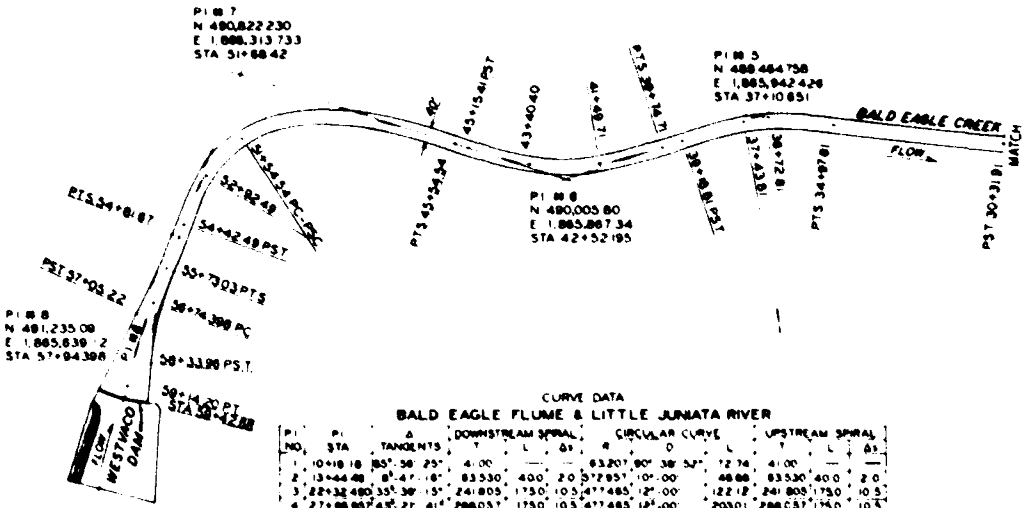
Photo 30. Failure in the type 2 riprap plan on the left slope (looking downstream) after a 15-hr (prototype) test with a 11,000-cfs discharge in Bald Eagle Creek and 29,300-cfs discharge in the Little Juniata River; TW el 889.18 (sta 131+00, Little Juniata River)



a. Gabions on right slope between sta 133+60 and 131+00

b. Gabions on left slope between sta 133+60 and 131+00

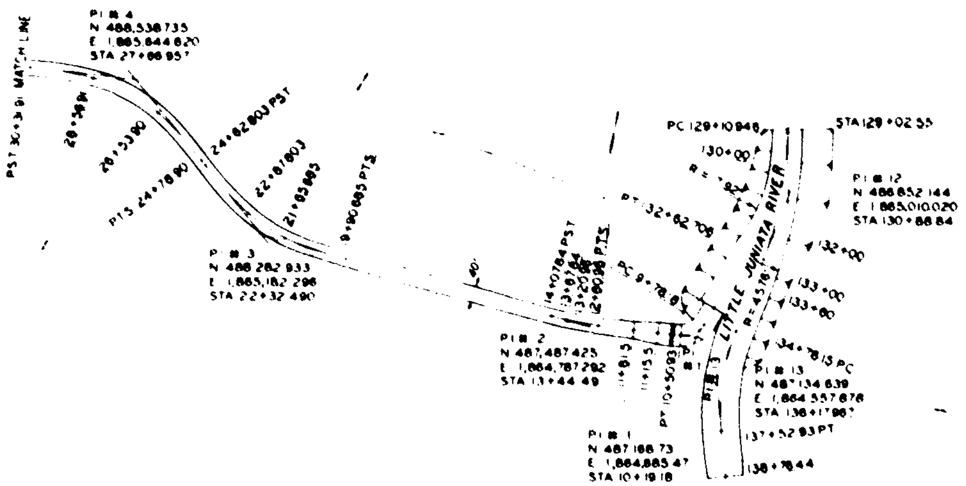
Photo 31. Looking downstream at gabion test sections on the bank slopes of the Little Juniata River



CURVE DATA

BALD EAGLE FLUME & LITTLE JUNIATA RIVER

P.I. NO.	P.I. STA	Δ TANGENTS	DOWNSTREAM SPIRAL T	DOWNSTREAM SPIRAL L	DOWNSTREAM SPIRAL θs	CIRCULAR CURVE R	CIRCULAR CURVE D	CIRCULAR CURVE L	UPSTREAM SPIRAL T	UPSTREAM SPIRAL L	UPSTREAM SPIRAL θs
1	10+19.18	85°-38'-25"	41.00	—	—	63.207	90°-38'-52"	72.74	41.00	—	—
2	13+44.49	8°-47'-16"	83.530	40.0	2.0	572.957	10°-00'	48.88	83.530	40.0	2.0
3	22+32.490	35°-38'-15"	241.805	175.0	10.5	477.465	12°-00'	122.12	241.805	175.0	10.5
4	27+86.957	45°-21'-41"	298.057	175.0	10.5	477.465	12°-00'	203.01	298.057	175.0	10.5
5	37+10.851	24°-38'-02"	212.845	175.0	8.75	572.957	10°-00'	71.01	212.845	175.0	8.75
6	42+52.195	30°-34'-11"	277.487	175.0	8.75	572.957	10°-00'	180.70	277.487	175.0	8.75
7	51+68.417	87°-12'-07"	813.878	600.0	51.0	320.963	17°-00'	137.93	438.018	150.0	12.75
8	57+94.398	5°-47'-08"	120.0	—	—	2468.7	2°-22'-14"	238.81	120.0	—	—
12	130+88.84	21°-08'-18"	177.80	—	—	954.93	6°-00'	351.78	177.80	—	—
13	138+17.867	20°-08'-18"	138.82	—	—	803.11	6°-30'	274.78	138.82	—	—



PLAN

PLAN
BALD EAGLE CREEK AND LITTLE JUNIATA RIVER

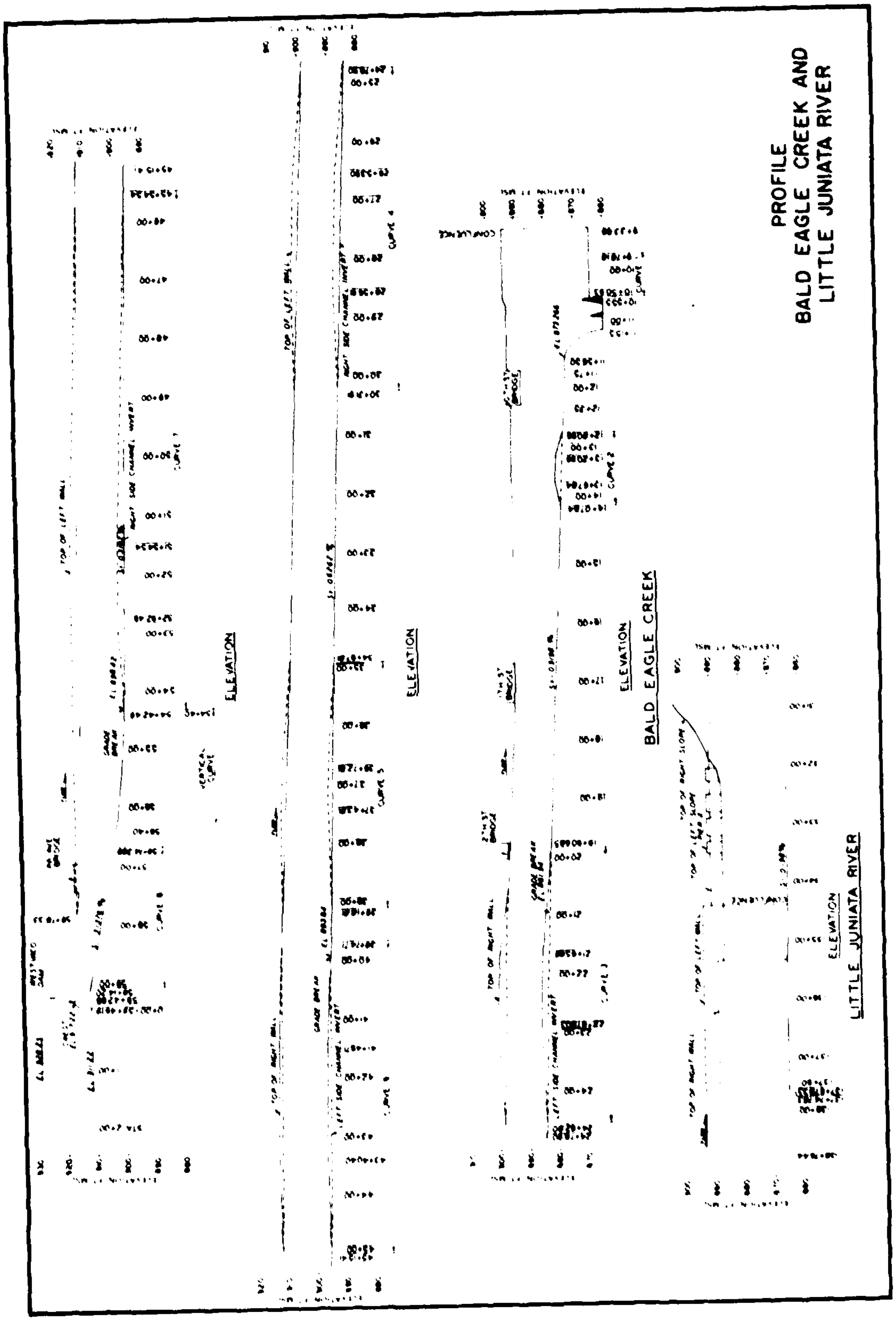

PROFILE
BALD EAGLE CREEK AND
LITTLE JUNIATA RIVER
ELEVATION
ELEVATION
ELEVATION
BALD EAGLE CREEK
ELEVATION
LITTLE JUNIATA RIVER

PLATE 2

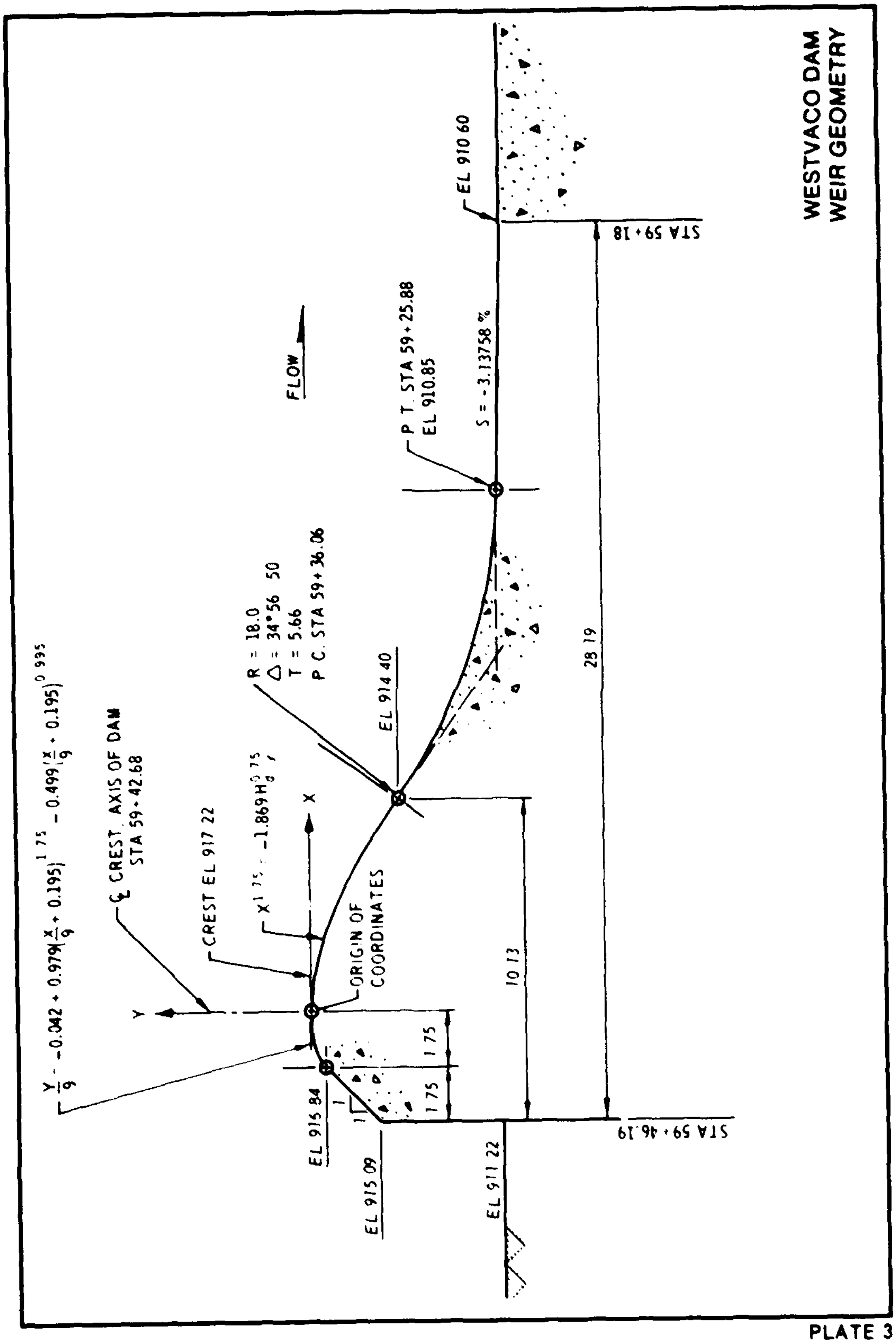

WESTVACO DAM
WEIR GEOMETRY
FLOW
EL 910 60
STA 59+18
P T. STA 59+25.88
EL 910.85
S = -3.13758 %
R = 18.0
Δ = 34°56' 50"
T = 5.66
P C. STA 59+36.06
EL 914 40
28 19
$\frac{Y}{9} = -0.342 + 0.979(\frac{X}{9} + 0.195)^{1.75} - 0.499(\frac{X}{9} + 0.195)^{0.995}$
℄ CREST. AXIS OF DAM
STA 59+42.68
CREST EL 917 22
$X^{1.75} = -1.869 H_d^{0.75} Y$
ORIGIN OF
COORDINATES
10 13
1 75
1 75
EL 915 34
EL 915 09
EL 911 22
STA 59+46.19

PLATE 3

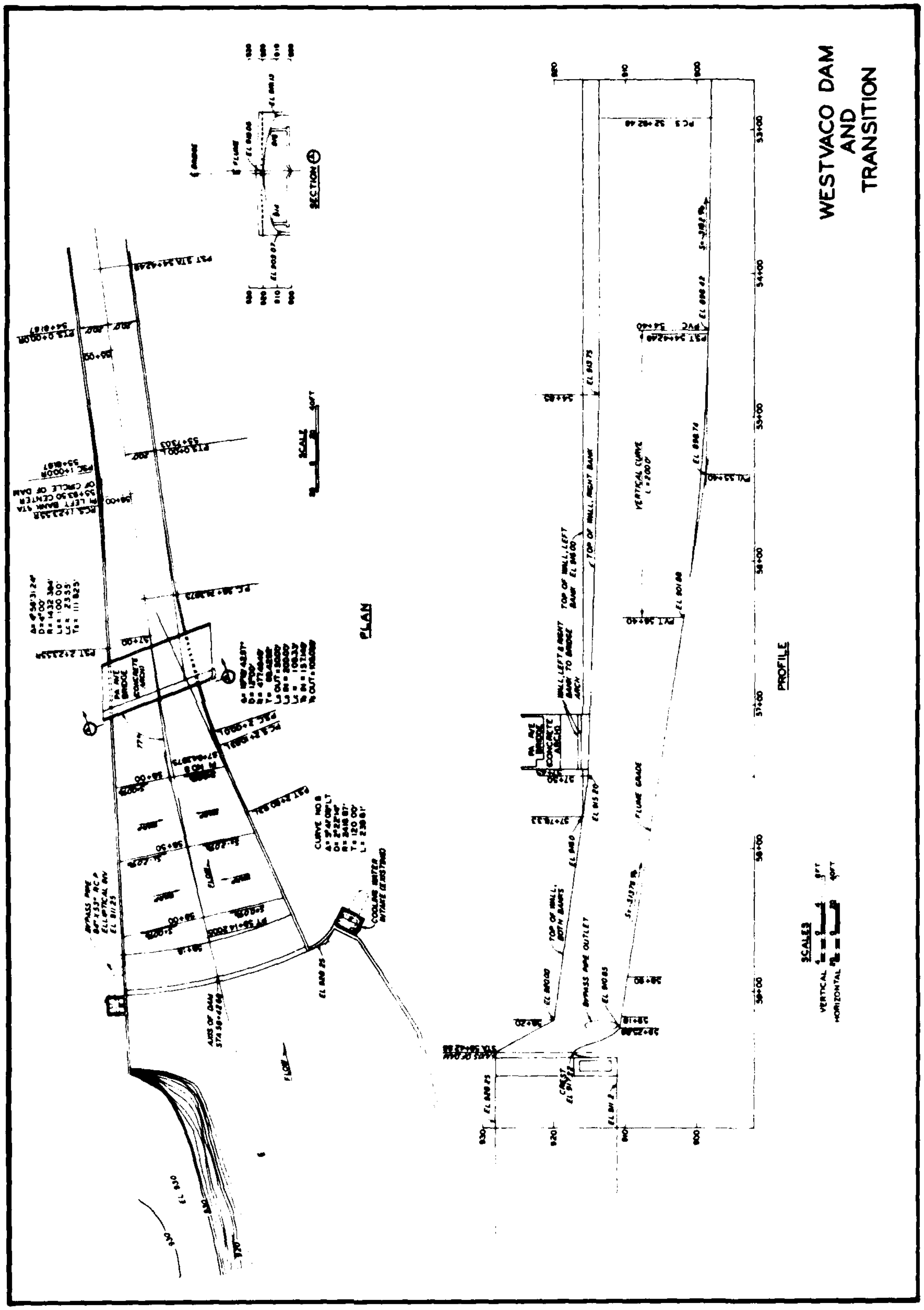
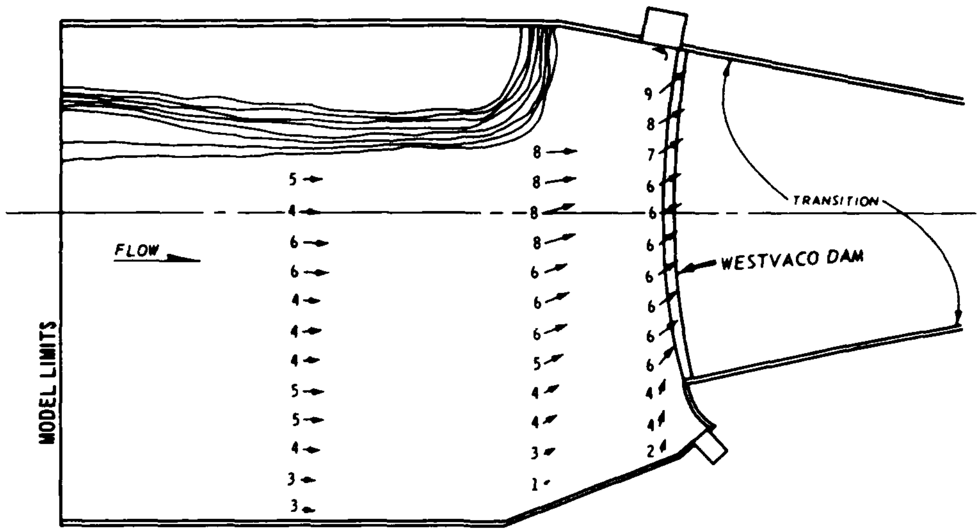
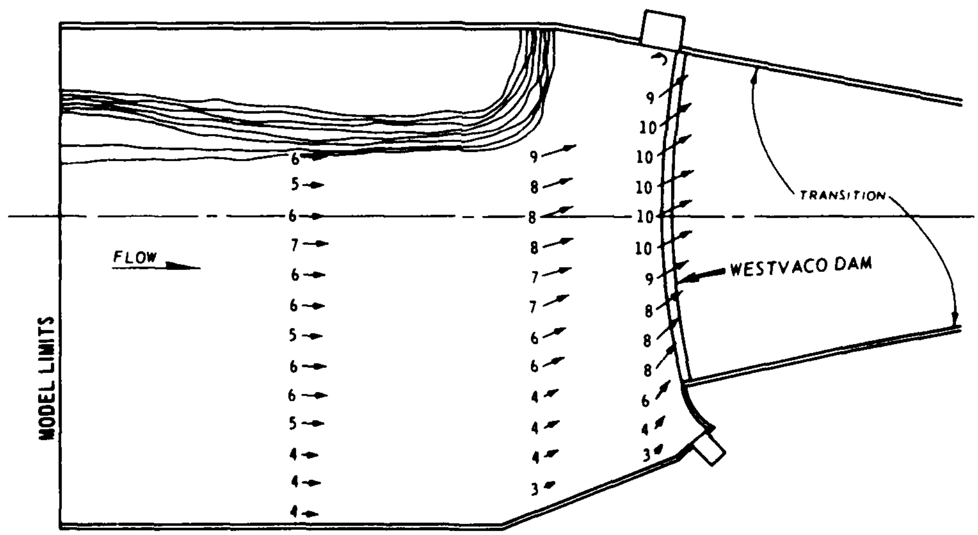

WESTVACO DAM
AND
TRANSITION
PLAN
PROFILE
SECTION A
SCALE
SCALES
VERTICAL
HORIZONTAL
VERTICAL CURVE
TOP OF WALL, RIGHT BANK
FLUME GRADE
BYPASS PIPE OUTLET
AXIS OF DAM
COOLING WATER INTAKE (EXISTING)
FLOW

PLATE 4



PLAN
(1 FT ABOVE CHANNEL INVERT)



PLAN
(7 FT ABOVE CHANNEL INVERT)

NOTE: VELOCITIES ARE IN PROTOTYPE FEET PER SECOND

MAXIMUM VELOCITIES
UPSTREAM OF WESTVACO DAM
TYPE 1 (ORIGINAL) DESIGN
DISCHARGE 13,400 CFS

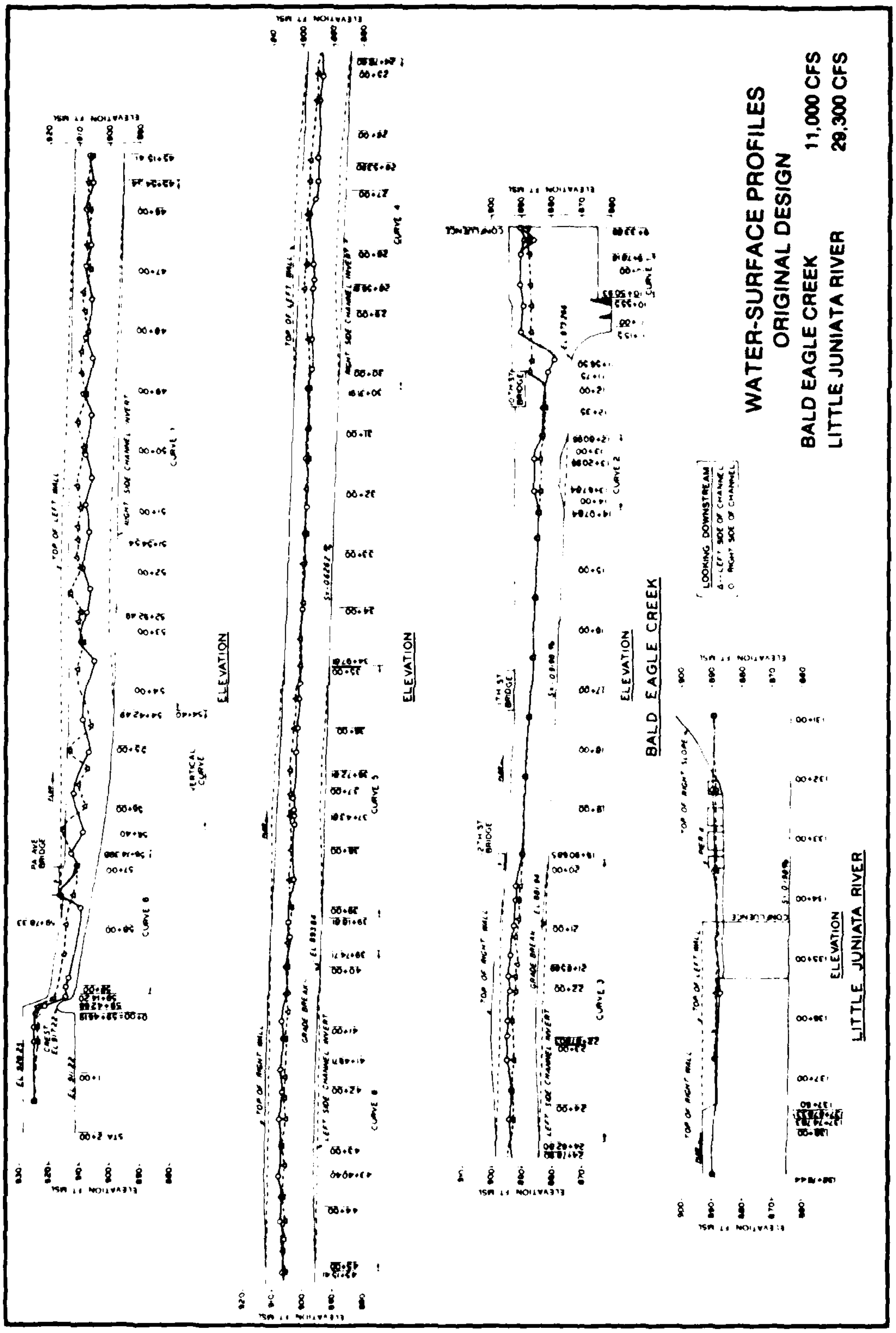

WATER-SURFACE PROFILES
ORIGINAL DESIGN
BALD EAGLE CREEK 11,000 CFS
LITTLE JUNIATA RIVER 29,300 CFS
ELEVATION
ELEVATION
ELEVATION
BALD EAGLE CREEK
ELEVATION
LITTLE JUNIATA RIVER
LOOKING DOWNSTREAM
ELEVATION FT MSL

PLATE 6

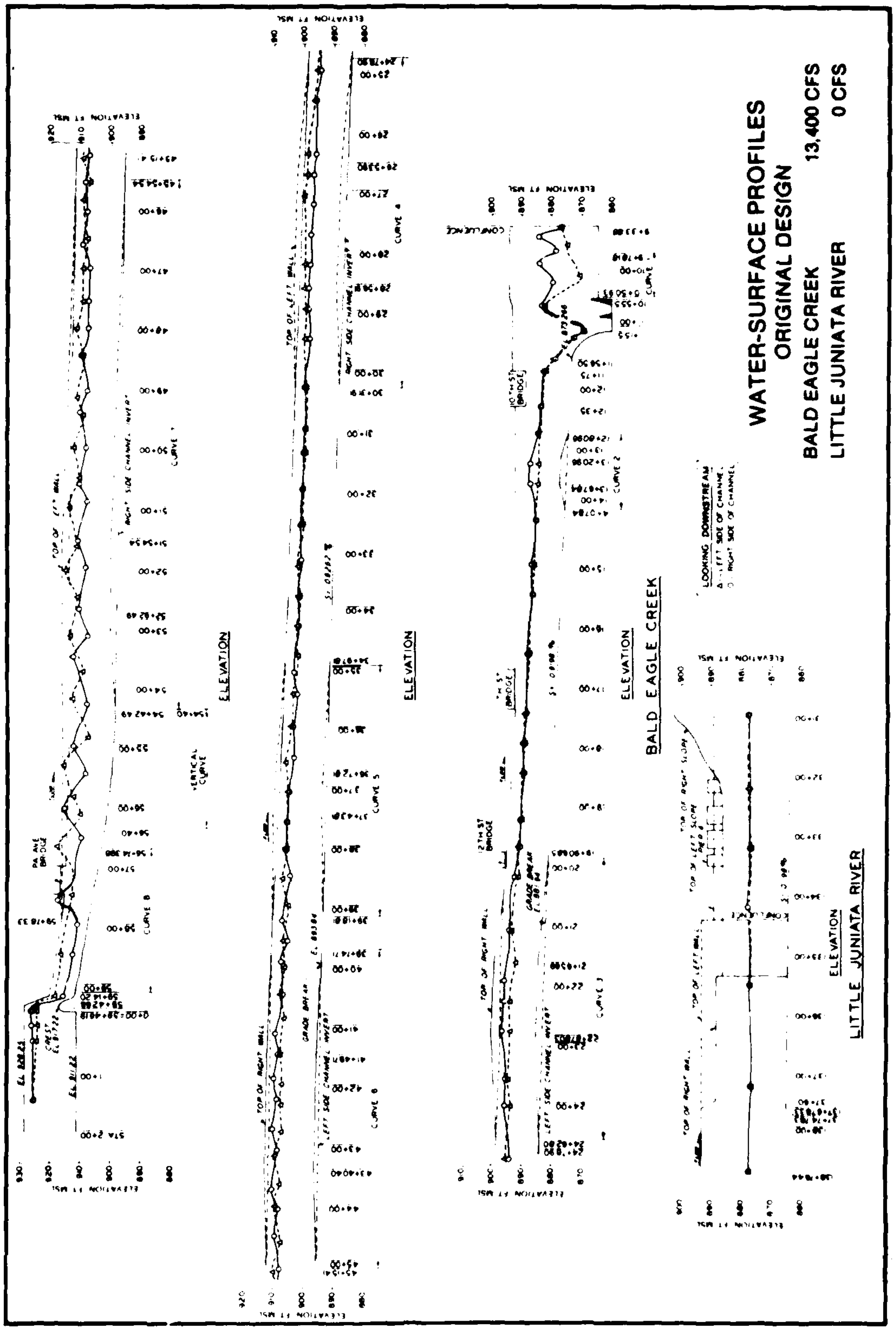
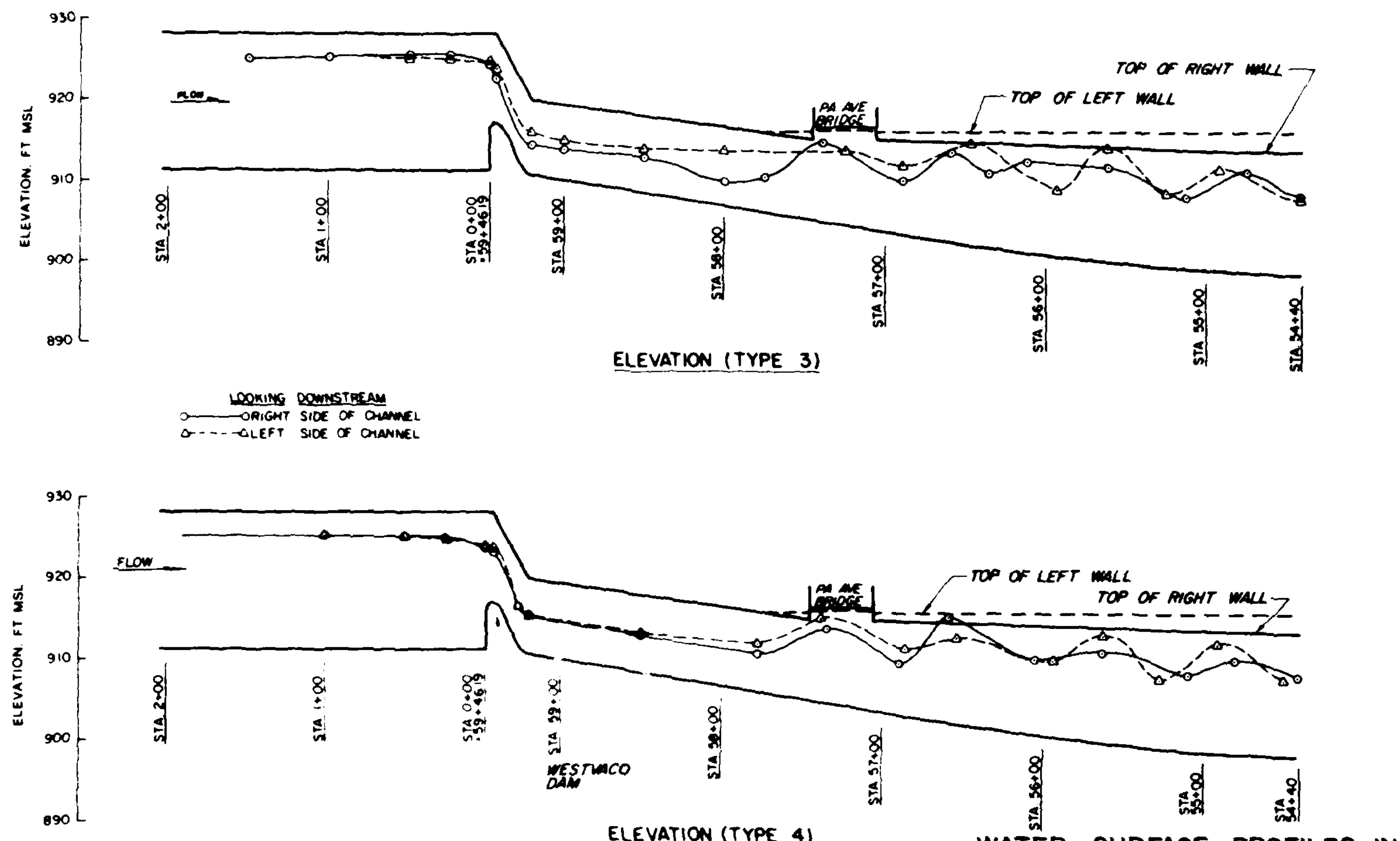
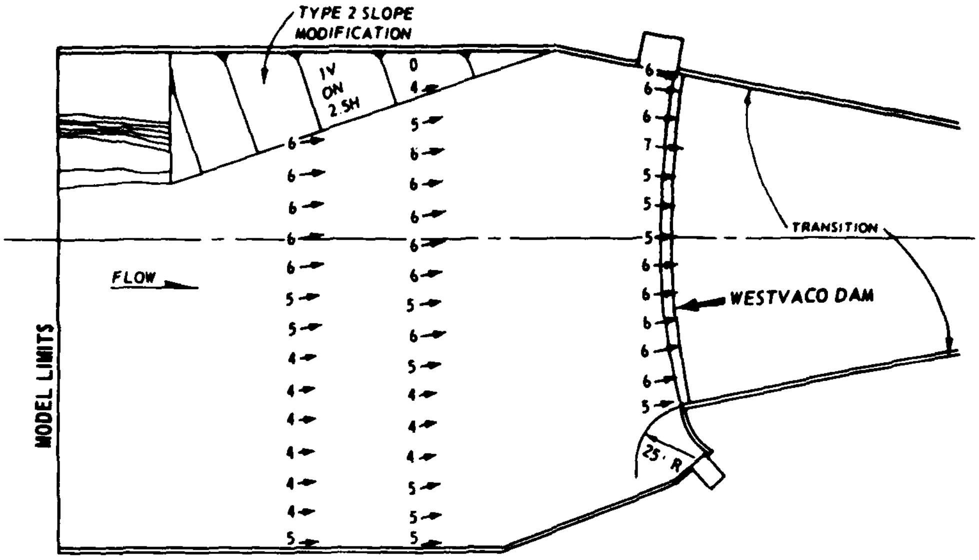

WATER-SURFACE PROFILES
ORIGINAL DESIGN
BALD EAGLE CREEK 13,400 CFS
LITTLE JUNIATA RIVER 0 CFS
ELEVATION
ELEVATION
ELEVATION
BALD EAGLE CREEK
ELEVATION
LITTLE JUNIATA RIVER
LOOKING DOWNSTREAM

PLATE 7

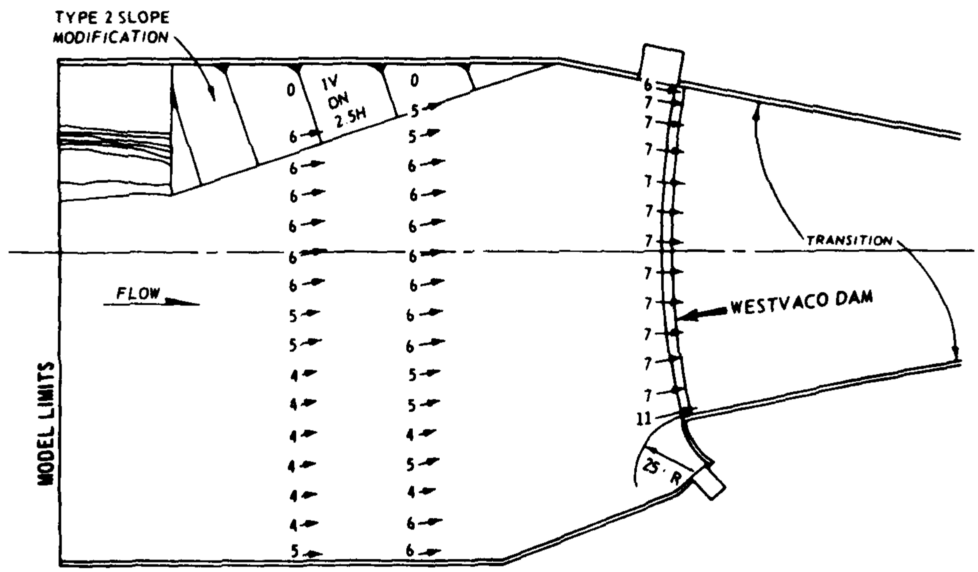


WATER-SURFACE PROFILES IN VICINITY OF WESTVACO DAM
TYPES 3 AND 4
DISCHARGE 13,400 CFS

PLATE 8



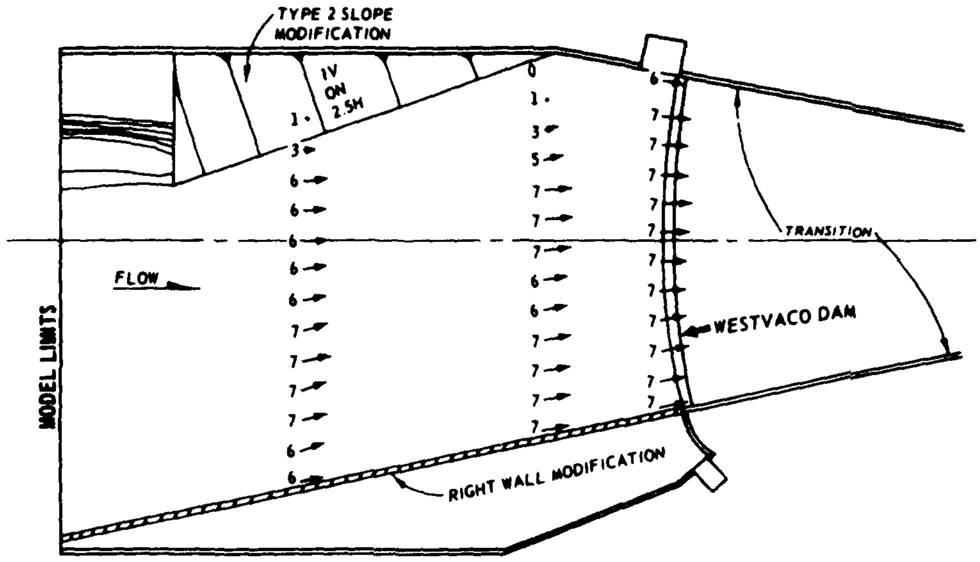
PLAN
(1 FT ABOVE CHANNEL INVERT)



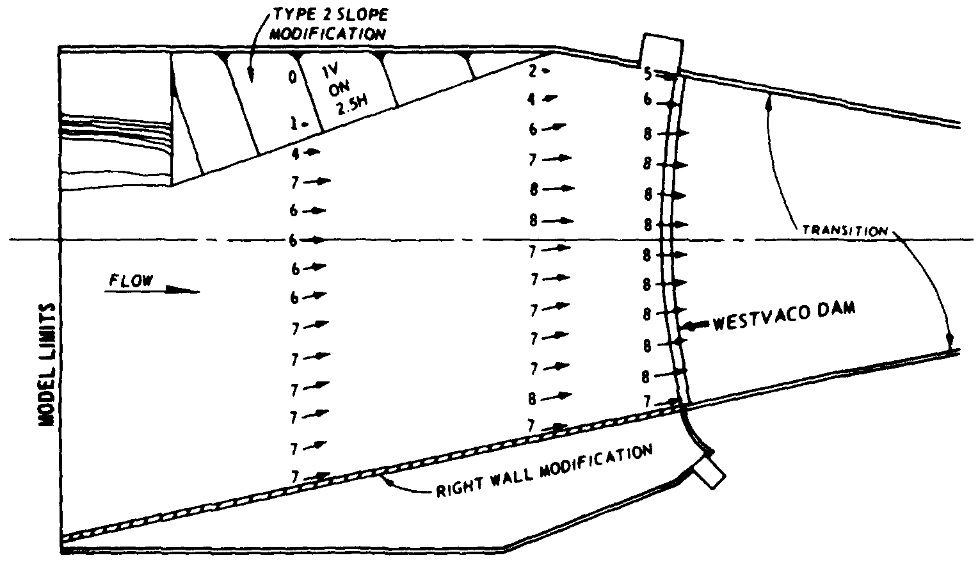
PLAN
(7 FT ABOVE CHANNEL INVERT)

NOTE: VELOCITIES ARE IN PROTOTYPE FEET PER SECOND

MAXIMUM VELOCITIES
UPSTREAM OF WESTVACO DAM
TYPE 3 MODIFICATION
DISCHARGE 13,400 CFS



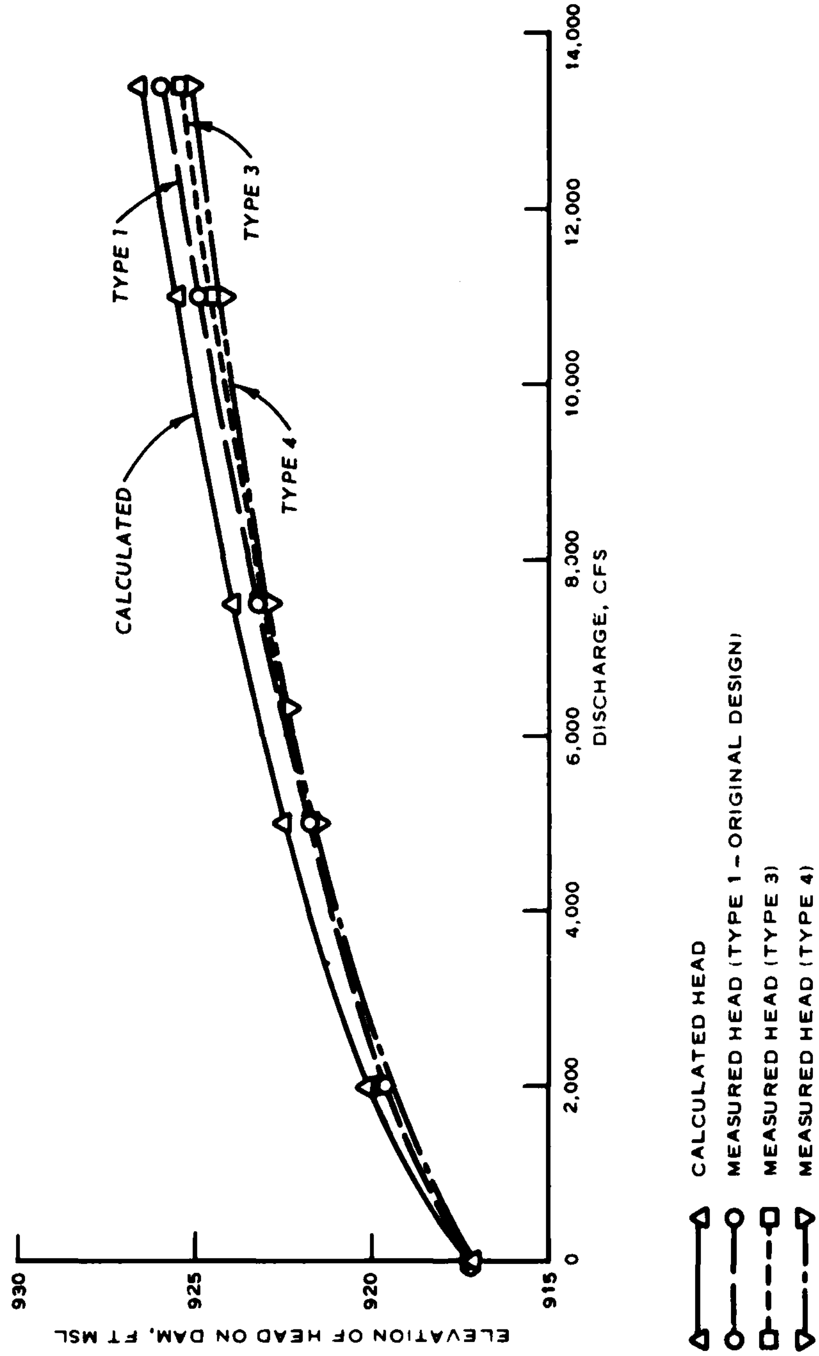
PLAN
(1 FT ABOVE CHANNEL INVERT)



PLAN
(7 FT ABOVE CHANNEL INVERT)

NOTE: VELOCITIES ARE IN PROTOTYPE FEET PER SECOND

MAXIMUM VELOCITIES
UPSTREAM OF WESTVACO DAM
TYPE 4 MODIFICATION
DISCHARGE 13,400 CFS



**HEAD ON WESTVACO DAM
MEASURED AND CALCULATED**

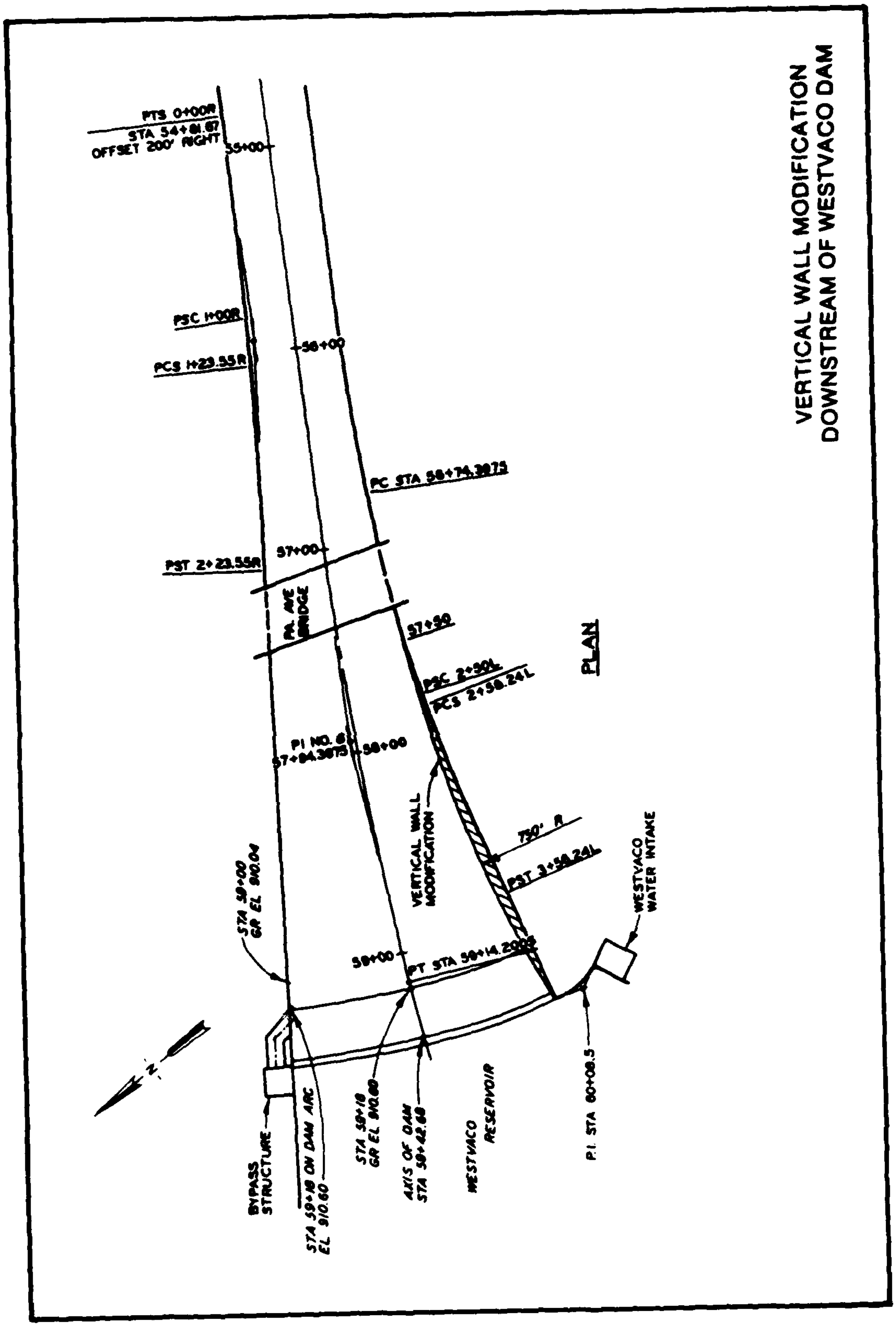
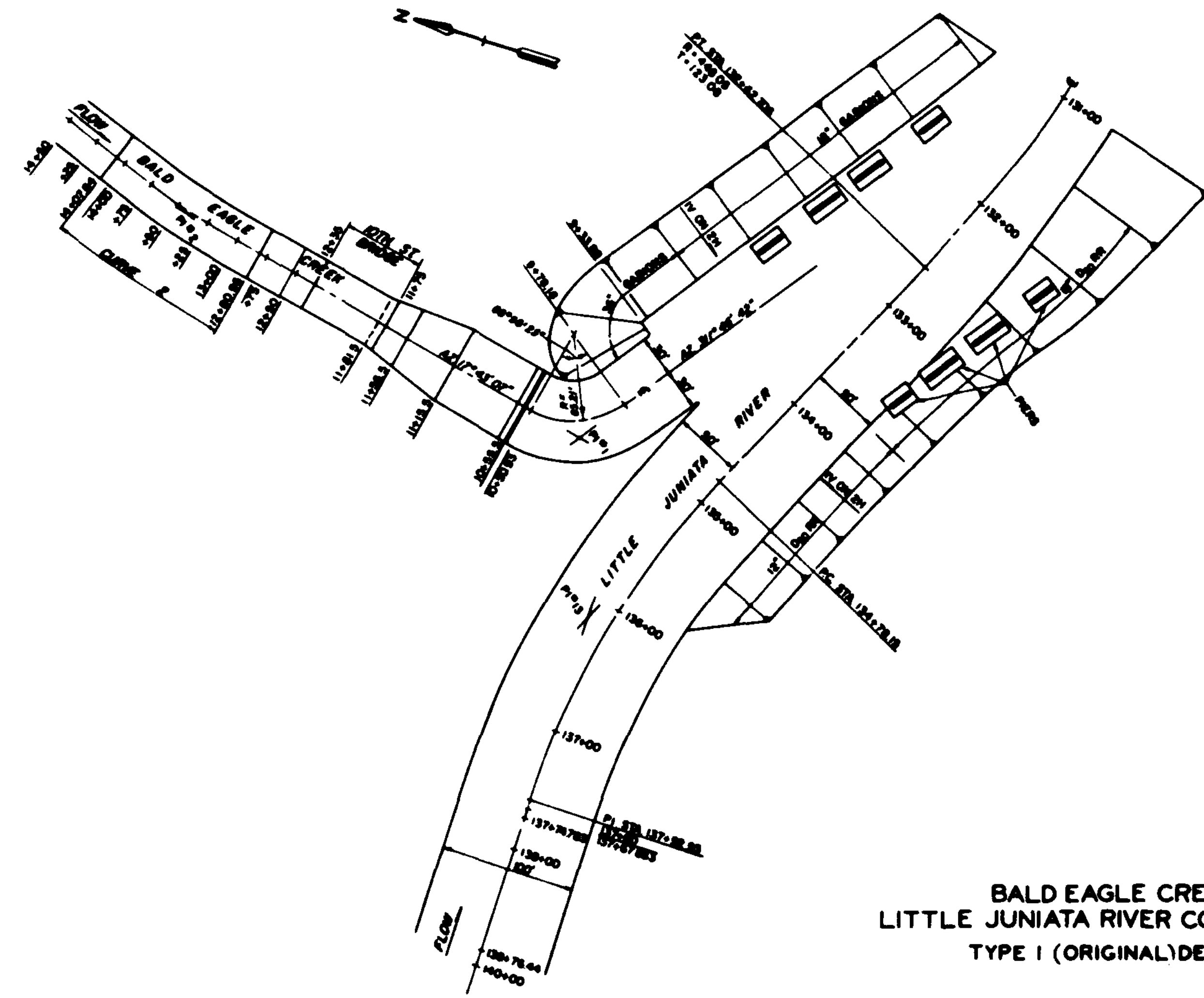
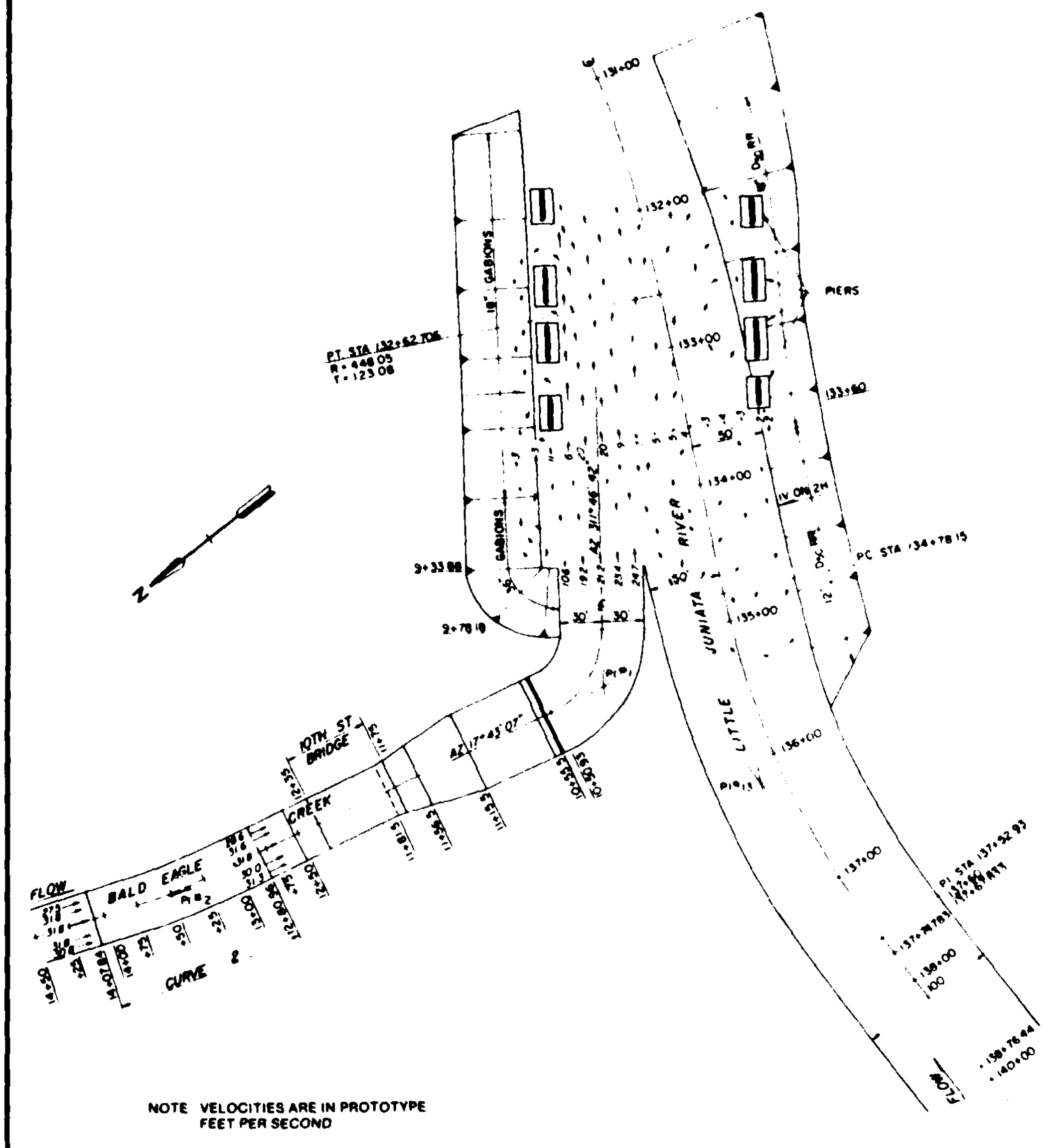

VERTICAL WALL MODIFICATION
DOWNSTREAM OF WESTVACO DAM
PLAN
PTS 0+00R
STA 54+81.67
OFFSET 200' RIGHT
55+00
PSC 1+00R
PCS 1+23.55R
56+00
PC STA 56+74.3875
PST 2+23.55R
57+00
PA. AVE BRIDGE
57+50
PSC 2+50L
PCS 2+58.24L
PI NO. 6
57+84.3875
58+00
VERTICAL WALL MODIFICATION
750' R
PST 3+58.24L
WESTVACO WATER INTAKE
STA 59+00
GR EL 910.04
59+00
PT STA 59+14.2005
BYPASS STRUCTURE
STA 59+18 ON DAM ARC
EL 910.60
STA 59+18
GR EL 910.60
AXIS OF DAM
STA 59+42.68
WESTVACO RESERVOIR
P.I. STA 60+08.5
N

PLATE 12

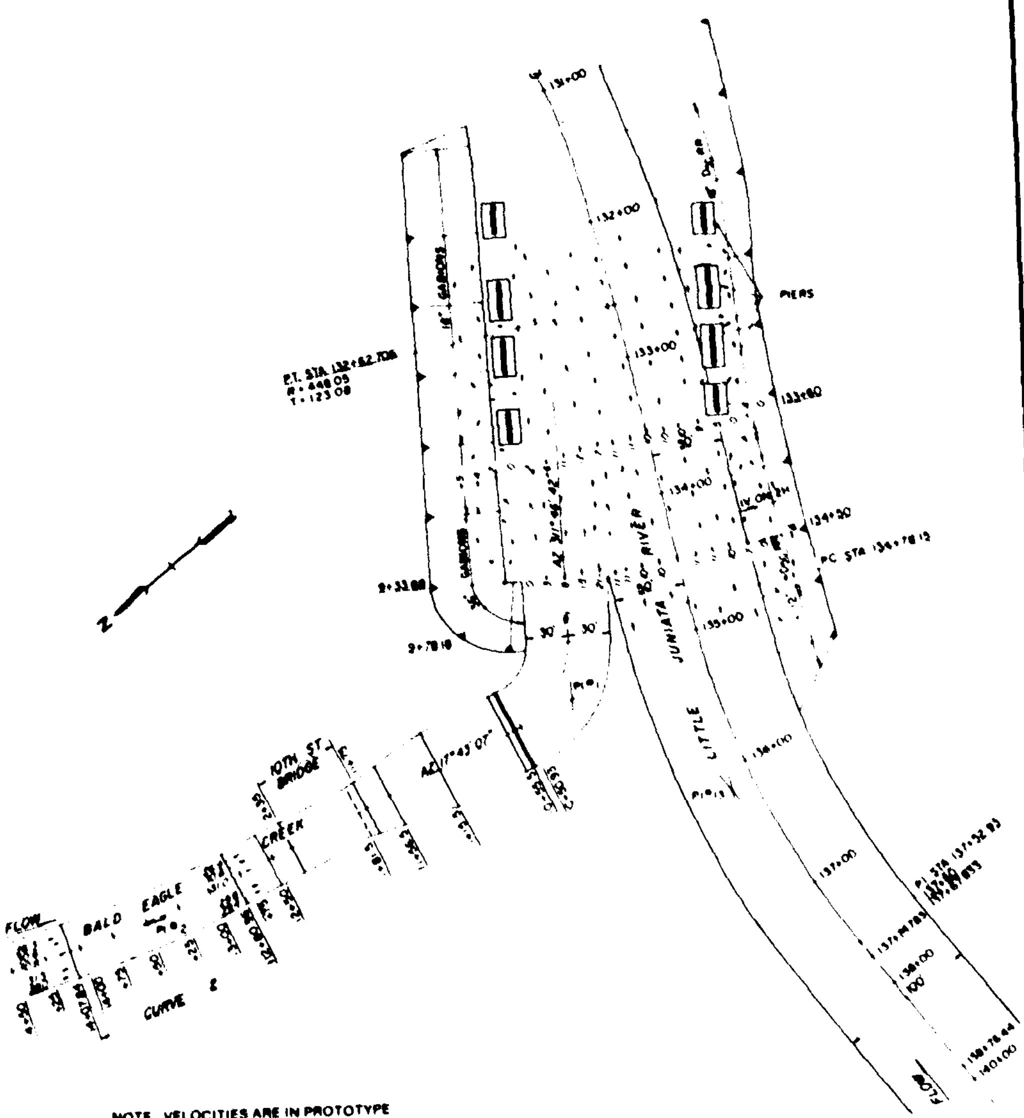


BALD EAGLE CREEK-
LITTLE JUNIATA RIVER CONFLUENCE
TYPE I (ORIGINAL) DESIGN



MAXIMUM VELOCITIES
1 FT ABOVE INVERT
ORIGINAL DESIGN
BALD EAGLE CREEK 13,400 CFS
LITTLE JUNIATA RIVER 0 CFS

PLATE 14



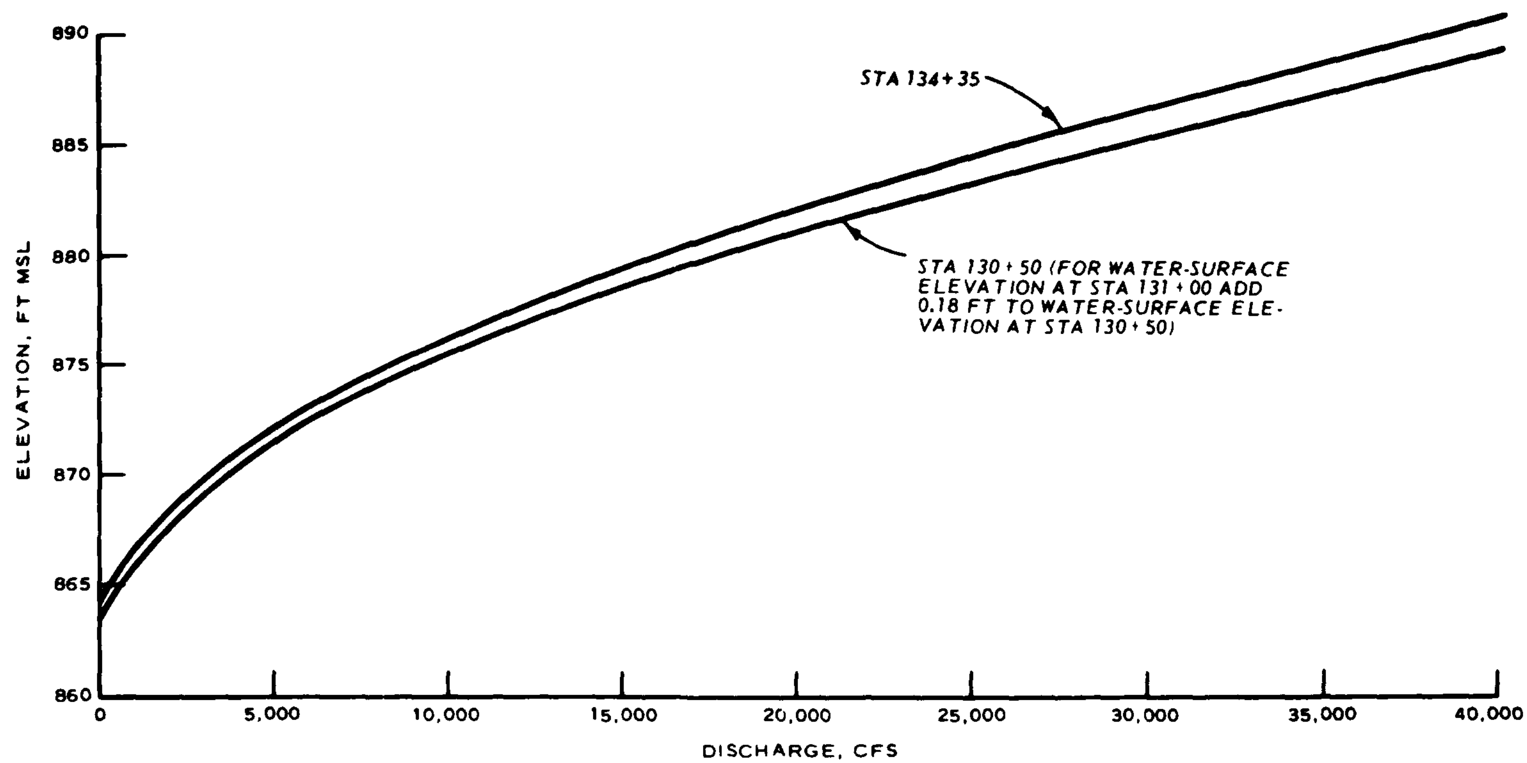
NOTE VELOCITIES ARE IN PROTOTYPE FEET PER SECOND

THIS PAGE IS BEST QUALITY PRACTICABLE FROM COPY FURNISHED TO DDC

MAXIMUM VELOCITIES
1 FT ABOVE INVERT
ORIGINAL DESIGN

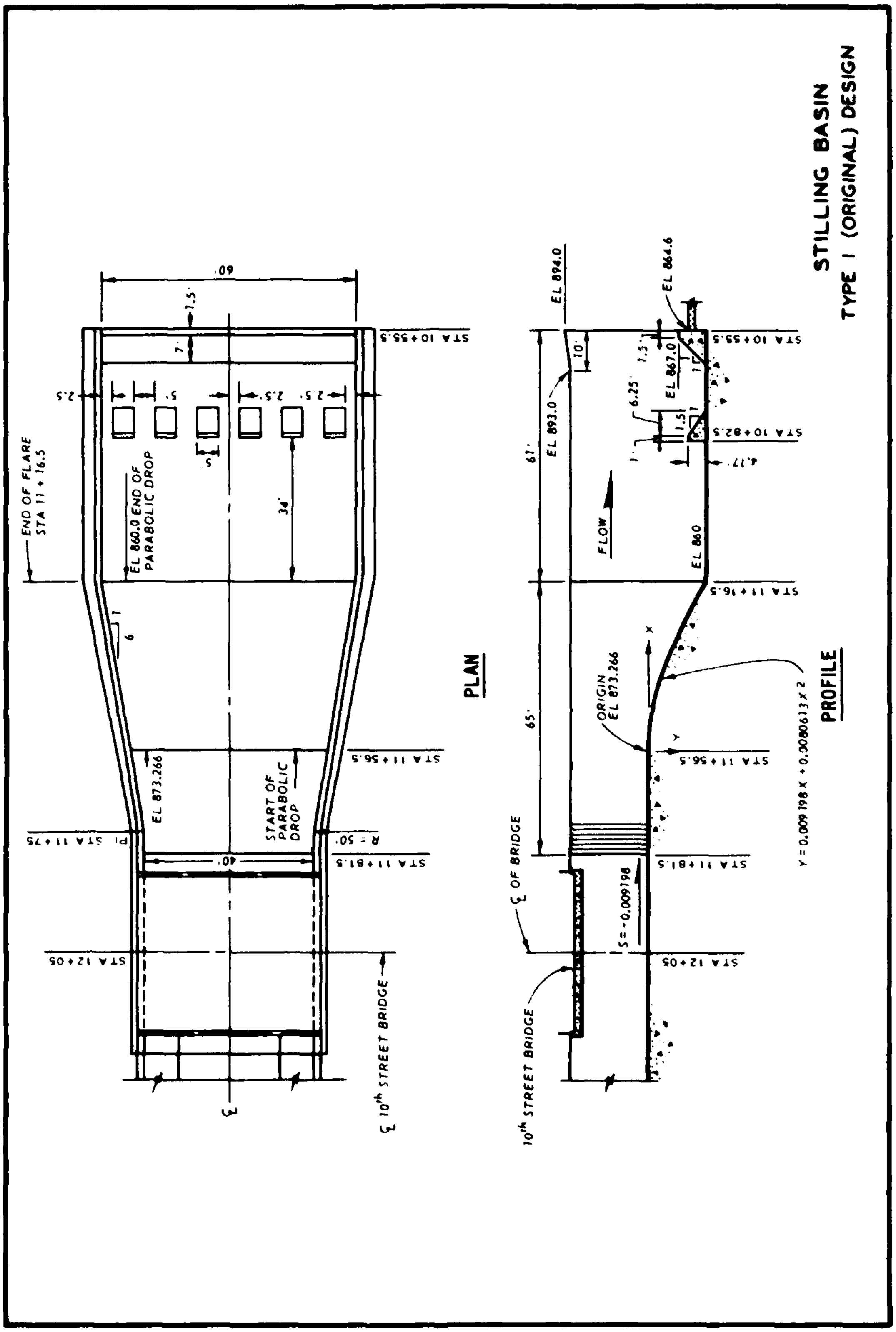
BALD EAGLE CREEK	11,000 CFS
LITTLE JUNIATA RIVER	29 300 CFS

PLATE 15

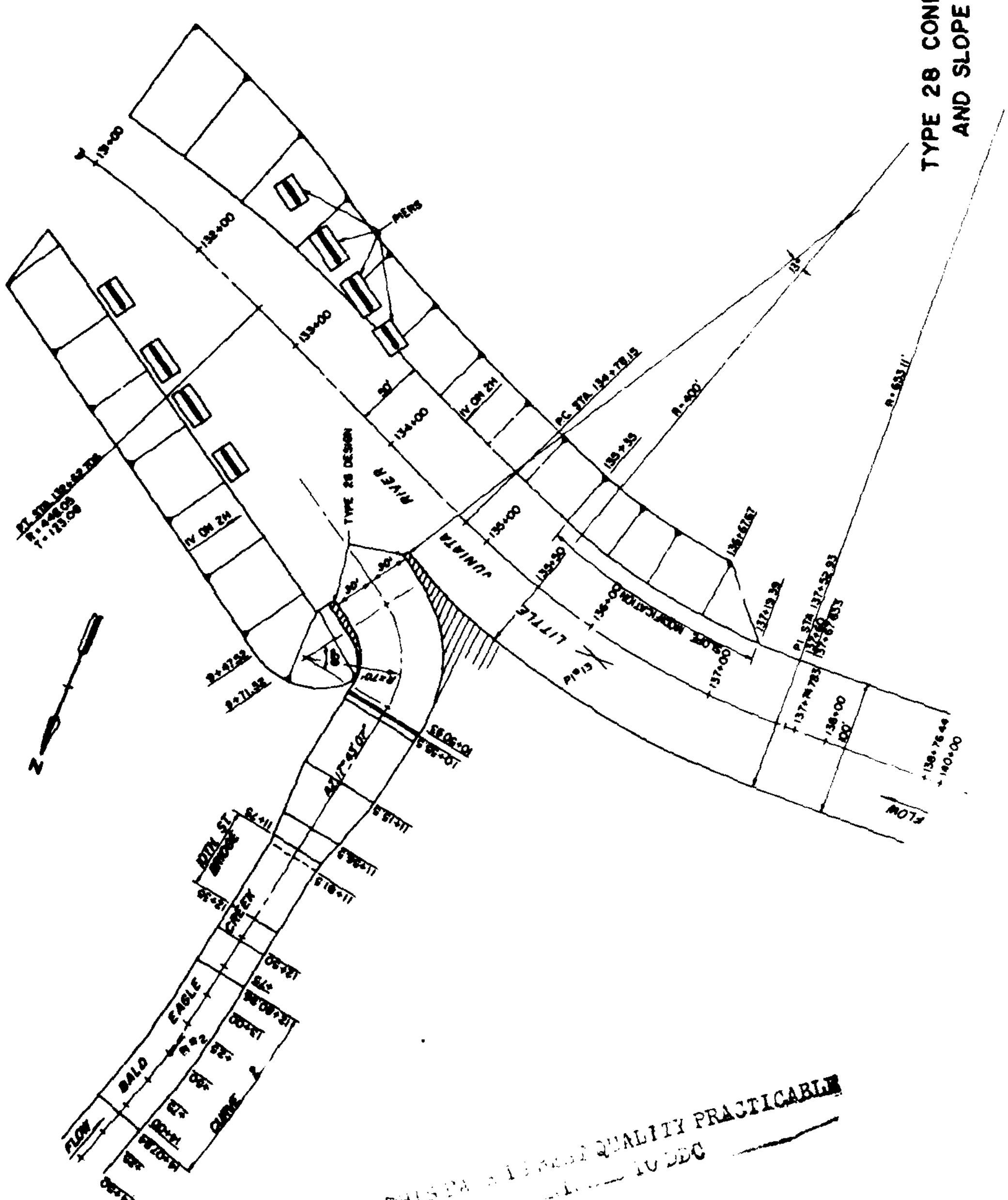


TAILWATER RATING CURVES
LITTLE JUNIATA RIVER

PLATE 16



STILLING BASIN
TYPE 1 (ORIGINAL) DESIGN



TYPE 28 CONFLUENCE DESIGN
AND SLOPE MODIFICATION

PLATE 18

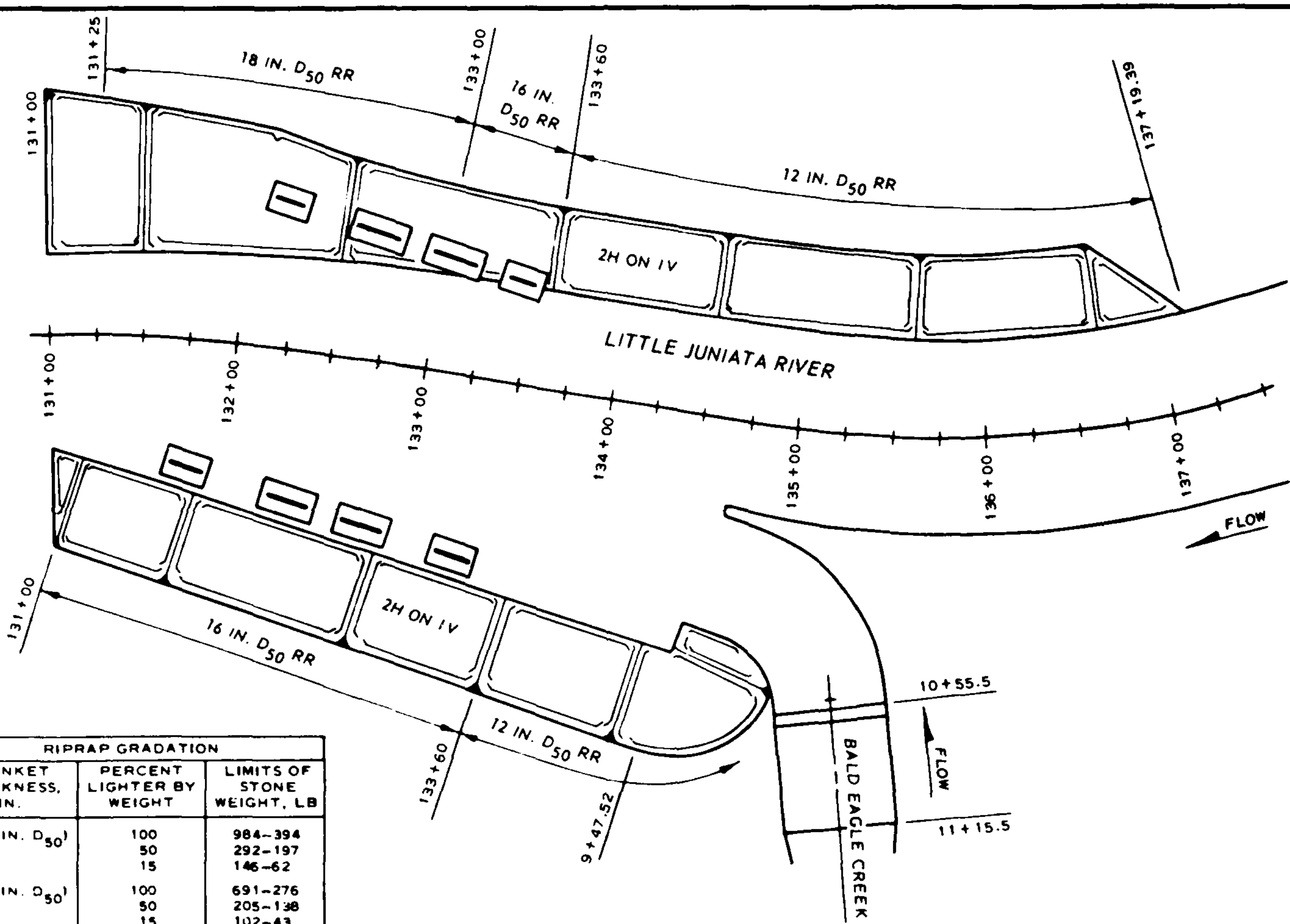
MAXIMUM VELOCITIES
1 FT ABOVE INVERT
TYPE 28 CONFLUENCE DESIGN WITH
SLOPE MODIFICATION
BALD EAGLE CREEK 13,400 CFS
LITTLE JUNIATA RIVER 0 CFS

PLATE 19

MAXIMUM VELOCITIES
1 FT ABOVE INVERT
TYPE 28 CONFLUENCE DESIGN WITH SLOPE MODIFICATION

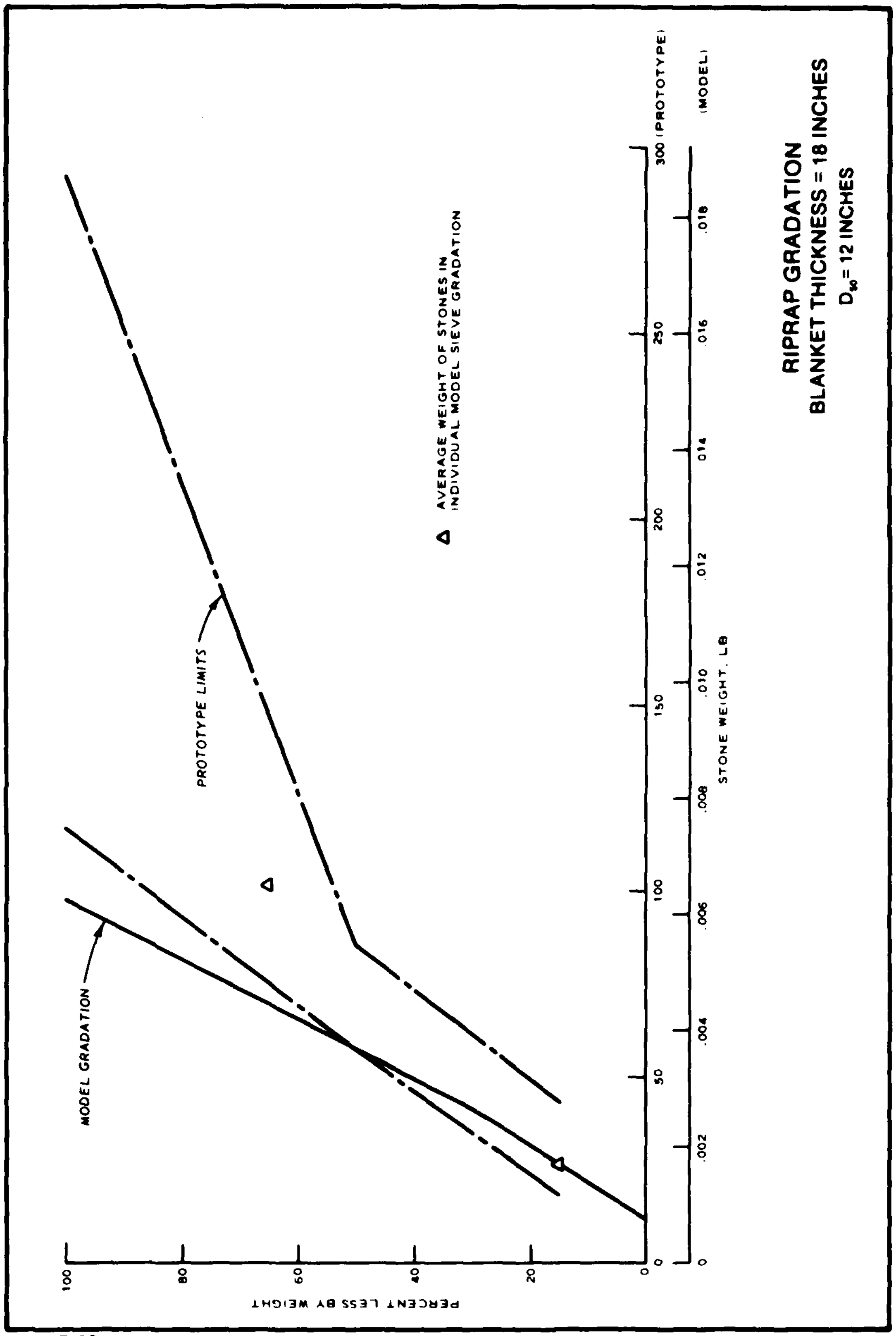
BALD EAGLE CREEK	11,000 CFS
LITTLE JUNIATA RIVER	29,300 CFS

PLATE 20

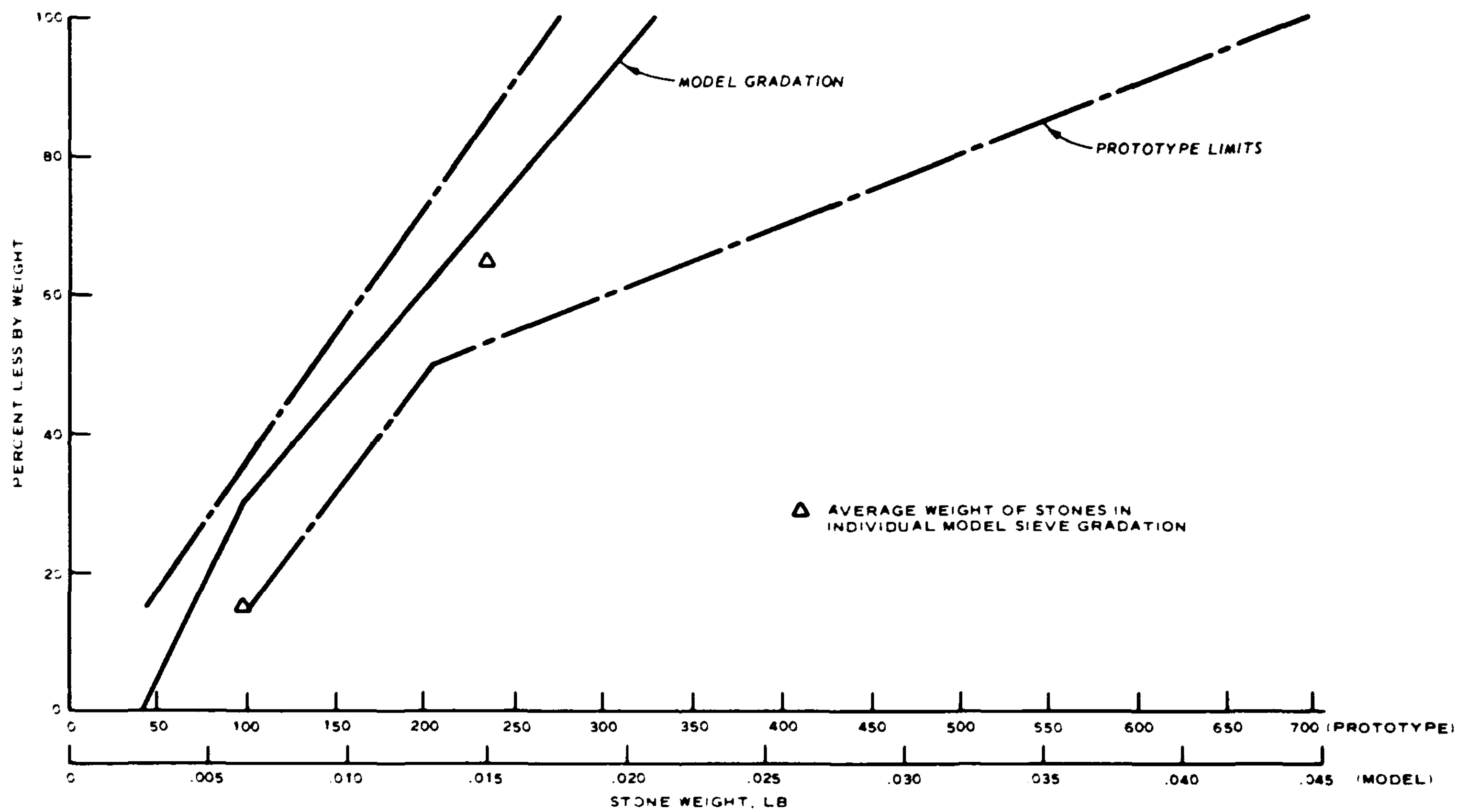


RIPRAP GRADATION		
BLANKET THICKNESS, IN.	PERCENT LIGHTER BY WEIGHT	LIMITS OF STONE WEIGHT, LB
27 (18 IN. D_{50})	100 50 15	984–394 292–197 146–62
24 (16 IN. D_{50})	100 50 15	691–276 205–138 102–43
18 (12 IN. D_{50})	100 50 15	292–117 86–58 43–18

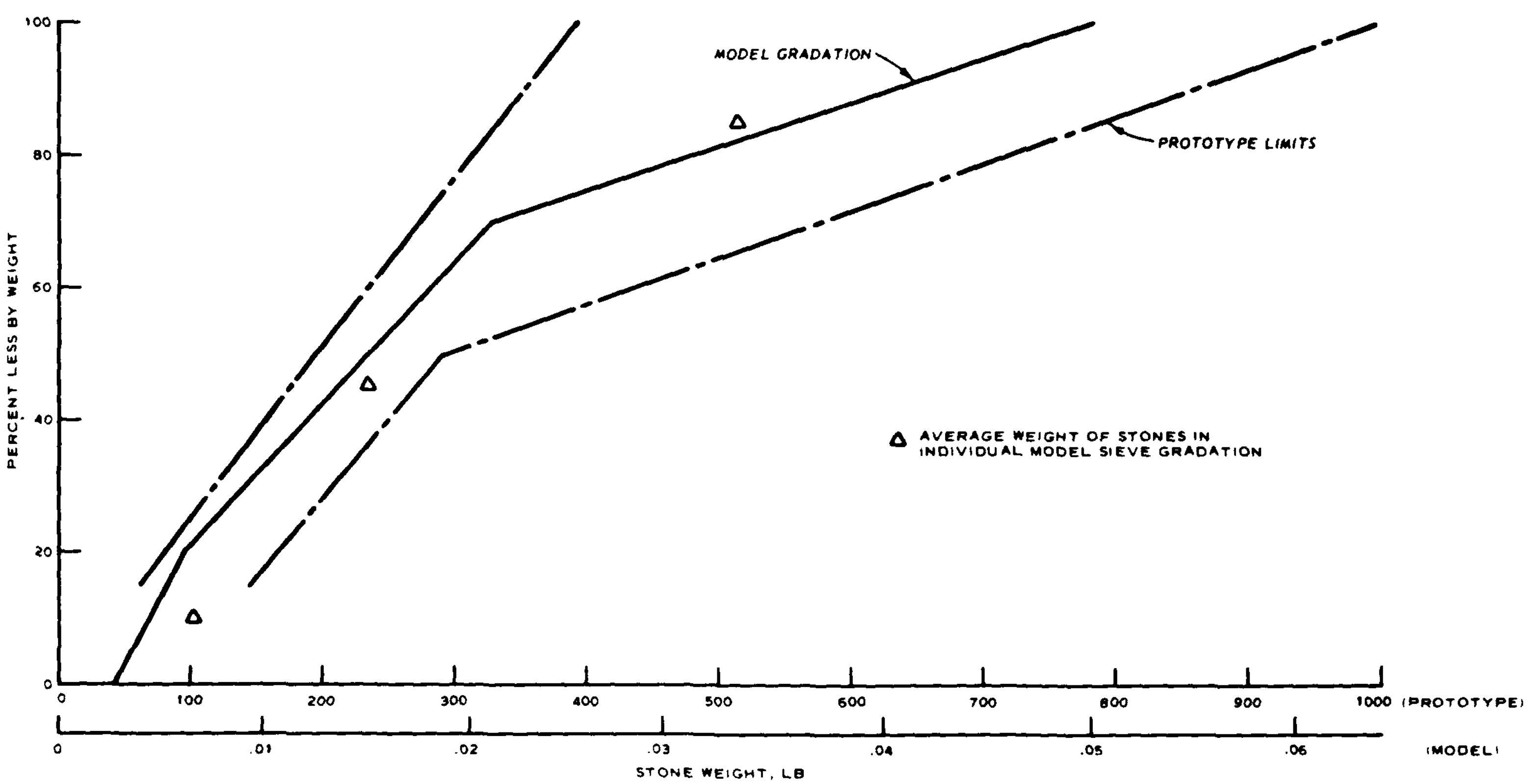
RIPRAP PLAN
TYPE 4



RIPRAP GRADATION
BLANKET THICKNESS = 18 INCHES
D_{50} = 12 INCHES



RIPRAP GRADATION
BLANKET THICKNESS = 24 INCHES
D_{50} = 16 INCHES



RIPRAP GRADATION
BLANKET THICKNESS = 27 INCHES
D_{50} = 18 INCHES

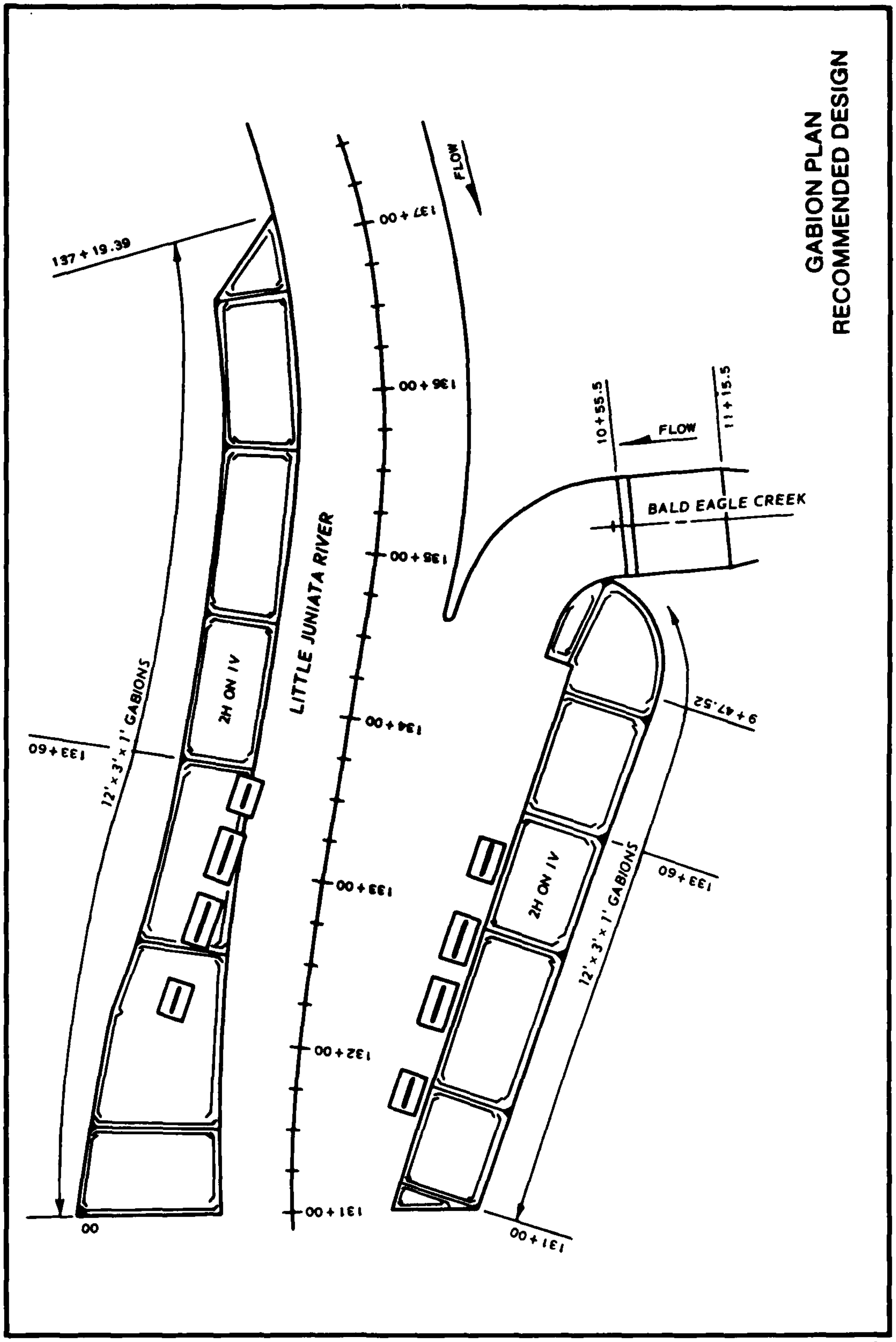

GABION PLAN
RECOMMENDED DESIGN
FLOW
137 + 00
136 + 00
135 + 00
134 + 00
133 + 00
132 + 00
131 + 00
137 + 19.39
133 + 60
12' x 3' x 1' GABIONS
2H ON 1V
LITTLE JUNIATA RIVER
00
10 + 55.5
11 + 15.5
FLOW
BALD EAGLE CREEK
9 + 47.52
2H ON 1V
133 + 60
12' x 3' x 1' GABIONS
131 + 00

PLATE 25

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

George, John F

Bald Eagle Creek and Little Juniata River channel improvement project; hydraulic model investigation / by John F. George. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1980.

21, [40] p., [13] leaves of plates : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; HL-80-5)

Prepared for U. S. Army Engineer District, Baltimore, Baltimore, Maryland.

1. Bald Eagle Creek. 2. Channel flow. 3. Channel improvement. 4. Hydraulic models. 5. Little Juniata River. I. United States. Army. Corps of Engineers. Baltimore District. II. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; HL-80-5.

TA7.W34 no.HL-80-5

DA

FILM

7-8